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8th European Magnetic Materials and Applications Conference

ABSTRACTS

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12. ABSTRACT (Maximum 200 words)

EMMA-2000 is the 8th in a series of biannual conferences on magnetism. The conference covered all aspects of magnetic materials, including basic, appled and technological topics. This volume contains abstracts of presented papers.

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8th EUROPEAN MAGNETIC MATERIALS AND APPLICATIONS CONFERENCE

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Yu.I. Yakimenko *(Exhibition)*
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GENERAL INFORMATION

DATE	June 7-10, 2000
LOCATION	Great Conference Hall NAS of Ukraine 55, Volodymyrs'ka str. Ukraine Teacher House 57, Volodymyrs'ka str.
ORGANIZATIONS	Institute of Magnetism National Academy of Sciences of Ukraine National Technical University of Ukraine "Kyiv Polytechnic Institute" Ukrainian URSI Committee

SPONSORS

European Physical Society

Science and Technology Center in Ukraine

Office of Naval Research International Field Office, Europe

National Academy of Sciences of Ukraine

SCOPE

EMMA-2000 is the 8th in a series of biannual conferences on magnetism. Previous meetings have been held in GRENOBLE (1985), SALFORD (1987), RIMINI (1989), DRESDEN (1991), KOSICE (1993), VIENNA (1995), and ZARAGOZA (1998). The conference will cover all aspects of magnetic materials, including basic, applied and technological topics. The objective is to provide a forum for researchers to discuss relevant and recent results on Magnetism.

SCIENTIFIC PROGRAM

Contribution will be accepted from the following areas:

1. Magnetic thin films, multilayers, surfaces, small particles, and their applications
2. Amorphous and nanocrystalline magnetic materials and applications
3. Hard magnetic materials, permanent magnets and their applications
4. Magnetoelasticity and magnetic anisotropy
5. Magnetic sensors devices and materials for electrical and electronic applications
6. Magnetic semiconductors, insulators and microwave applications
7. Magnetization processes and their mechanism
8. Micromagnetic calculations
9. Strong magnetic fields and high pressures.
10. Magnetic recording
11. Molecular magnetism and magnetic polymers. Ferrofluids. Applications.
12. Biomagnetism
13. Magnetic measurement techniques
14. Magneto-optics and applications
15. Magneto-transport and Hall effect, GMR, CMR, materials and applications
16. Magnetic separation and levitation.
17. Rare earth intermetallics
18. Novel magnetic phases and interstitials. Itinerant magnetism
19. Basic problems of physics of magnetic materials
20. Soft magnetic materials and applications

In the frame of the conference a special seminar "Selected topics of dynamics and structure of magnetic materials" in memorizing of Professor A. Hubert will be held.

CONFERENCE SITE

All events associated with EMMA-2000 will take place in the Great Conference Hall of the National Academy of Sciences of Ukraine (55, Volodymyrs'ka str.) and Ukraine Teacher House (57, Volodymyrska str.). Both buildings are situated in the center of the town close to metro (subway) stations and hotels (*see* Schemes of the arrangement).

CLIMATE

The weather in Kyiv at the beginning of June is usually warm and sunny. The average temperature in June is +25^{0}C. The climate in Ukraine is a mild, moderate continental.

TIME

Local time is one hour ahead of Middle European time.

TRAVEL INFORMATION

Kyiv can be easily reached by plane (airports Borispol and Zhuljany) or train. There are direct flights from New York, London, Frankfurt, Munich, Berlin, Paris, Rome, Zurich, Brussels, Vienna, Amsterdam, Barcelona, Prague, Warsaw. There is a shuttle bus from the airport to the center of the town. The shuttle bus makes a station near hotel 'Ukraina'.

LOCAL ORGANIZING COMMITTEE

Local Organizing Committee for assistance to the participants will be open at the Great Conference Hall of the NAS of Ukraine on June 6 - 10. 2000 from 10 until 18.00 p.m.

CONFERENCE LANGUAGES

The official language of the conference (abstracts, papers, proceedings, lectures, posters and information) is English.

MEALS

There are many snack bars and restaurants close to the Conference Site and in the center of the town.

PRESRNTATION

The Conference will include six general plenary lectures, thirty one invited lectures and contributed papers. Sixty two contributed presentations were be selected for parallel oral presentations, the others will be presented in the form of posters. An industrial exhibition is planned. The Conference language is English.

Invited talks:	30 minutes (including discussion)
Selected talks	15 minutes (including discussion)
Poster:	Maximum 1.40m x 1.00m

Overhead projectors (codoscopes, A4) are available. The slides should be well legible in a distance of nearly 15m away of the projection screen.

The poster should be placed on the board with a number of the paper according to the program in the beginning of the each conference day. Each poster is open for the entire duration of the conference day. The organizers will supply material for attaching the poster to the poster board.

CONFERENCE PROCEEDINGS

The Proceedings of the Conference will be published by Trans Tech Publications Ltd. as a special volume of the 'Materials Science Forum' (ISSN: 0255-5476, ISSN/ISO: Mater.Sci.Forum., Online Catalogue on the Internet: http://www.ttp.net). Papers to be published in the Conference Proceedings are subject to strict length and format requirements. The length of INVITED papers is limited to 6 printed pages A4. The length of CONTRIBUTED papers is limited to 4 printed pages A4.

Owing to the limitations imposed by publisher we unfortunately compelled to set a rule that **each registered participant can only submit one manuscript.**
All papers will go through the regular procedure of refereeing prior to the Conference. The final decision on revised versions will be made before the end of the Conference. Technical facilities (Microsoft Word and Tex) for minor corrections of the manuscript are planned to be provided.

SOCIAL PROGRAMME

General information

KYIV

Kyiv is the capital of Ukraine, one of the most ancient cities in the world. It is known in history as the "Mother of Russian cities", the capital of the first Eastern-Slavonic state, the Kyiv Russ. Kyiv played an important role in the development of the world culture. It was founded in the VI century. And from here Christianity, adopted by Prince Vladimir in 988, started spreading in Russ.

Kyiv is a major scientific center. It is the seat of the National Academy of Sciences of Ukraine, dozens of research and design organizations, many institutions of higher education.

Kyiv is one of largest cultural centers. There are many remarkable monuments of history and architecture (St. Sophia Cathedral - XI-XVIII centuries, the Golden Gates - XI, the Kyiv-Pechery Lavra - 1051, St. Cyril Church - XII, etc.).

Abundance of plants made Kyiv famous as the city-park. Woods, gardens, parks and tree-lined boulevards take more than 60% of its area. Kyiv is situated on the banks of the Dnipro, this making it inimitable in its charm.

GET TOGETHER PARTY: Will take place at June 6, 2000 from 19:00 to 21:00.

Another Conference events to be announced at the Conference registration desk during the Conference.

ACCOMPANYING PERSON PROGRAMME: The Get Together Party, Conference Banquet and refreshments during Coffee Break at the Conference are included in the registration fees. Cultural activities and excursions will be organized taking into account the number of registered accompanying persons. Information about sightseeing visits in Kyiv will be available at the Conference registration desk.

MAILING ADDRESS

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Institute of Magnetism NAS of Ukraine
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http://im.imag.kiev.ua/emma2000.html

LIST OF INVITED LECTURES AND ORAL PRESENTATIONS

Schedule of EMMA-2000 Conference

	Wednesday 7 June		Thursday 8 June		Friday 9 June		Saturday 10 June	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**
9.00			Th-IA01	Th-IB01	Fr-IA01	Fr-IB01	Sa-IA01	Sa-IB01
9.30			Th-IA02	Th-IB02	Fr-IA02	Fr-IB02	Sa-IA02	Sa-IB02
10.00	**Opening**		Th-OA01	Th-OB01	Fr-OA01	Fr-OB01	Sa-OA01	Sa-IB03
10.15			Th-OA02	Th-OB02	Fr-OA02	Fr-OB02	Sa-OA02	
10.30			Th-OA03	Th-OB03	Fr-OA03	Fr-OB03	Sa-OA03	Sa-OB01
10.45			Th-OA04	Th-OB04	Fr-OA04	Fr-OB04	Sa-OA04	Sa-OB02
11.00	Coffee break							
11.30	We-IG01		Th-IA03	Th-IB03	Fr-IA03	Fr-IB03	Sa-IG01	
11.45								
12.00	We-IG02		Th-OA05	Th-OB05	Fr-OA05	Fr-OB05	Sa-IG02	
12.15			Th-OA06	Th-OB06	Fr-OA06	Fr-OB06		
12.30	We-IG03		Th-OA07	Th-OB07	Fr-OA07	Fr-OB07	Sa-IG03	
12.45			Th-OA08	Th-OB08	Fr-OA08	Fr-OB08		
13.00	Lunch						**Closing Session**	
14.00	We-IA01	We-IB01	Th-IA04	Th-IB04	Fr-IA04	Fr-IB04		
14.30	We-IA02	We-IB02	Th-IA05	Th-IB05	Fr-IA05	Fr-IB05		
15.00	We-IA03	We-IB03	Th-OA09	Th-IB09	Fr-OA9	Fr-OB09		
15.15			Th-OA10	Th-IB10	Fr-OA10	Fr-OB10		
15.30	Coffee Break		Th-OA11	Th-IB11	Fr-OA11	Fr-OB11		
15.45			Th-OA12	Th-IB12	Fr-OA12	Fr-OB12		
16.00	We-OA01	We-OB01	Posters Th-PBnnn		Posters Fr-PBnnn			
16.15	We-OA02	We-OB02	Topics 05, 06, 08, 10,		Topics 02, 03, 04, 07,			
16.30	We-OA03	We-OB03	11, 12, 13, 16, 18, 19,		17			
16.45	We-OA04	We-OB04	20					
17.00	Posters We-Pannn							
18.00	Topics 01, 14, 15							
19.00								

Invited lectures – I
General session – G
Parallel sessions – A, B
Oral contributions – O
Poster presentations – P

EMMA-2000, June 7-10, 2000, Kyiv, Ukraine
LIST OF INVITED LECTURES AND ORAL PRESENTATIONS

Wednesday, June 7, 2000 GENERAL SESSION

11.30-12.00 **We-IG01**
J.M.D. Coey, G.Hinds and T.R.Ni Mhiochain (Ireland)
"MAGNETIC FIELD EFFECTS IN ELECTRODEPOSITION"

12.00-12.30 **We-IG02**
J.C. Slonczewski (USA)
"MAGNETIC EXCITATION WITH SPIN-POLARIZED CURRENT"

12.30-13.00 **We-IG03**
J.S. Moodera (USA)
"SPIN POLARIZED TUNNELING"

LUNCH

Wednesday, June 7, 2000 Section A

INVITED LECTURES

14.00-14.30 **We-IA01**
H.R. Khan (Germany)
"LOW FIELD MAGNETORESISTANCE IN PEROVSKITE STRUCTURE MANGANITES"

14.30-15.00 **We-IA02**
V.V. Ustinov, A.B.Rinkevich, L.N.Romashev (Russia)
"HIGH-FREQUENCY ANALOGUES OF GIANT MAGNETORESISTANCE IN MAGNETIC SUPERLATTICES"

15.00-15.30 **We-IA03**
A.P. Shpak, A.B. Shevchenko, A.B. Melnik (Ukraine)
"MAGNETIC PROPERTIES OF SMALL FERROMAGNETIC PARTICLES OF THE VARIOUS SYMMETRY"

Coffee break

Oral presentations

16.00-16.15 **We-OA01**
I.O. Troyanchuk, D.D. Khalyavin, E.F. Shapovalova, K. Baerner, H. Szymczak
"EFFECT OF Mn-SUBSTITUTION WITH Zn, Cu, Co, Cr, Al, Ti, Nb ON MAGNETIC AND TRANSPORT PROPERTIES OF $La_{0.7}Sr_{0.3}(Mn_{1-x}Me_x)O_3$"

16.15-16.30 **We-OA02**
W. Westerburg, D. Reisinger, F. Martin, and G. Jakob
"MAGNETO-TRANSPORT AND HALL EFFECT IN Sr_2FeMoO_6 THIN FILMS"

16.30-16.45 **We-OA03**
N.N. Loshkareva, Yu.P.Sukhorukov, E.V.Panfilova, E.A.Neifeld, V.E.Arkhipov, A.V.Korolev, V.S.Gaviko, Ya.M.Mukovskii, D.A.Shulyatev
"LOCALIZED AND DELOCALIZED STATES IN OPTICAL SPECTRA OF LANTHANUM MANGANITES"

LIST OF INVITED LECTURES AND ORAL PRESENTATIONS

Wednesday, June 7, 2000 Section A

16.45-17.00 **We-OA04**
A. Llobet, L. Ranno, J. Pierre
"TUNING MAGNETOTRANSPORT AND MAGNETIC PROPERTIES OF $La_{2/3}Ca_{1/3}MnO_3$ THIN FILMS USING EPITAXIAL STRAIN"

Wednesday, June 7, 2000 Section B

INVITED LECTURES

14.00-14.30 **We-IB01**
H. Kronmuller (Germany)
"COERCIVITY AND COERCIVITY MECHANISMS OF NANOCRYSTALLINE PERMANENT MAGNETS"

14.30-15.00 **We-IB02**
K. Ouchi and N. Honda (Japan)
"DEVELOPMENT OF RECENT PERPENDICULAR MAGNETIC RECORDING MEDIA"

15.00-15.30 **We-IB03**
D.J. Mapps (United Kingdom)
"A SCENARIO FOR FUTURE INFORMATION STORAGE SYSTEMS"

Coffee break

Oral presentations

16.00-16.15 **We-OB01**
V.V. Grimalsky, Yu.G. Rapoport, C.E. Zaspel, A.N. Slavin
"NUMERICAL MODELING OF WAVE FRONT REVERSAL FOR TWO-DIMENSIONAL SPIN WAVE PACKETS IN MAGNETIC FILMS"

16.15-16.30 **We-OB02**
H. Gomonaj
"MAGNETOELASTIC MECHANISM OF THE MAGNETIC INTERACTION IN THE MAGNETIC/NONMAGNETIC MULTYLAYERS"

16.30-16.45 **We-OB03**
Y.K. Fetisov and C.E. Patton
"MICROWAVE FOLDOVER AND BISTABILITY IN NONLINEAR FERROMAGNETIC RESONANCE"

16.45-17.00 **We-OB04**
Yu.I. Gorobets, S.V. Gorobets
"FORMATION OF THE DIRECTED FLOWS IN SOLUTIONS OF ACIDS AND SALTS IN THE VICINITY OF HIGH GRADIENT FERROMAGNETIC PACKING IN A CONSTANT MAGNETIC FIELD"

EMMA-2000, June 7-10, 2000, Kyiv, Ukraine
LIST OF INVITED LECTURES AND ORAL PRESENTATIONS
Thursday, June 8, 2000 Section A

INVITED LECTURES

9.00-9.30 **Th-IA01**
A.I. Shames, **E. Rozenberg**, G. Gorodetsky and M. Greenblatt (Israel)
"EMR STUDIES OF SOME DOPED La-BASED MANGANITES"

9.30-10.00 **Th-IA02**
G.A. Gehring (United Kingdom)
"THE INSULATING PHASE OF MANGANITES"

Oral presentations

10.00-10.15 **Th-OA01**
K.V. Kamenev, W.G. Marshall, M.R. Lees, D. McK.Paul, G. Balakrishnan, V.G.Tissen, M.V. Nefedova
"PRESSURE EFFECTS ON THE MAGNETIC AND STRUCTURAL PROPERTIES OF LAYERED MANGANITES"

10.15-10.30 **Th-OA02**
O. Crisan, J.M.Le Breton, A. Jianu, A. Maignan, M. Nogues, J. Teillet, G.Filoti
MAGNETIC PROPERTIES OF THE MAGNETORESISTIVE Cu-($SmCo_5$)-Fe HETEROGRANULAR ALLOYS"

10.30-10.45 **Th-OA03**
Y.P. Lee, V.G. Prokhorov, K.W. Kim, J.Y. Rhee, G.G. Kaminsky, and V.F.Flis
"CHARGE ORDERING AND INSULATOR-METAL TRANSITION OF EPITAXIAL $Pr_{1-x}Ca_xMnO_3$ FILMS"

10.45-11.00 **Th-OA04**
R.S. Freitas, L. Ghivelder, F. Damay and L.F. Cohen
"EVOLUTION FROM FERROMAGNETIC ORDER TO CLUSTER GLASS BEHAVIOR IN $La_{0.7-x}Y_xCa_{0.3}MnO_3$ MANGANITES"

Coffee Break

INVITED LECTURE

11.30-12.00 **Th-IA3**
M.R. Ibarra and J.M. De Teresa (Spain)
"NEW PHENOMENA RELATED TO THE COLOSSAL MAGNETORESITANCE EFFECTS IN MIXED VALENCE MANGANITES"

Oral presentations

12.00-12.15 **Th-OA05**
A.B. Rinkevich, A.P. Nossov, V.V. Ustinov, V.G. Vassiliev, E.V.Vladimirova, B.V. Slobodin
"RADIO FREQUENCY MAGNETIC FIELD PENETRATION THROUGH LANTHANUM MANGANITES"

Thursday, June 8, 2000 Section A

12.15-12.30 **Th-OA06**
E.L. Nagaev
"A THEORY OF COLOSSAL MAGNETORESISTANCE Pr- AND Nd-BASED MANGANITES"

12.30-12.45 **Th-OA07**
D.I. Khomskii
"NOVEL TYPE OF ORBITAL ORDERING : COMPLEX ORBITALS IN THE COLOSSAL MAGNETORESISTANCE MANGANITES"

12.45-13.00 **Th-OA08**
M.I. Auslender, E. Rozenberg, G. Gorodetsky
"LOW-TEMPERATURE MINIMUM OF RESISTIVITY AND MAGNETORESISTANCE IN CERAMIC MANGANITES: AN INTERGRAIN TUNNELING MODEL VERSUS EXPERIMENT"

LUNCH

INVITED LECTURES

14.00-14.30 **Th-IA04**
B. Koopmans, M. van Kampen, J.T. Kohlhepp, and W.J.M. de Jonge (The Netherlands)
"FEMTOSECOND MAGNETO-OPTICS: SPIN DYNAMICS IN FERROMAGNETIC LAYERED SYSTEMS"

14.30-15.00 **Th-IA05**
Th. Rasing (The Netherlands)
"NONLINEAR MAGNETO-OPTICS"

Oral Presentations

15.00-15.15 **Th-OA09**
O.A. Aktsipetrov, T.V. Murzina, A.N. Pogorily, A.F. Kravets, A.Ya. Vovk, and N. Kotov
"NONLINEAR OPTICS OF MAGNETIC NANOPARTICLES"

15.15-15.30 **Th-OA10**
S. Knappmann, E. Stavrou, K. Roll
"LASER BEAM ASSISTED KERR MICROSCOPY FOR INVESTIGATIONS OF NEW MAGNETO-OPTICAL STORAGE LAYERS"

15.30-15.45 **Th-OA11**
N. Adachi, V.P. Denysenkov, S.I. Khartsev and A.M. Grishin
"MAGNETIC AND MAGNETOOPTICAL PROPERTIES OF $Bi_3Fe_5O_{12}$ (100) THIN FILM PREPARED BY PULSED LASER DEPOSITION"

15.45-16.00 **Th-OA12**
E.A. Gan'shina, N.I. Tsidaeva, A.A. Bogoroditsky, R.U. Kumaritova, G.V.Smirnitskaya
"MAGNETO-OPTICAL INVESTIGATION OF Fe(x) /Pd (30Å) MULTILAYERS"

EMMA-2000, June 7-10, 2000, Kyiv, Ukraine

LIST OF INVITED LECTURES AND ORAL PRESENTATIONS

Thursday, June 8, 2000 Section B

INVITED LECTURES

9.00-9.30 **Th-IB01**
S.M. Ryabchenko, A.F. Lozenko, V.M. Kalita, P.O. Trotsenko (Ukraine)
"INVESTIGATION OF MAGNETO-ELASTIC DOMAINS IN EASY-PLANE ANTIFERROMAGNETS"

9.30-10.00 **Th-IB02**
A.S. Ermolenko (Russia)
"ALLOYAGE INFLUENCE ON THE STRUCTURE AND MAGNETIC PROPERTIES OF 3d – 4f INTERMETALLICS"

Oral presentations

10.00-10.15 **Th-OB01**
Yu.A. Izyumov, B.M. Letfulov
"A SIMPLIFIED DOUBLE-EXCHANGE MODEL IN THE DYNAMICAL MEAN-FIELD APPROXIMATION"

10.15-10.30 **Th-OB02**
V.A. Ivanov, V.V. Moshchalkov
"SUPERCONDUCTIVITY WITH ANGULAR DEPENDENT COUPLING: STRIPES, COULOMB REPULSION AND ENHANCED T_C"

10.30-10.45 **Th-OB03**
A. Pimenov, Ch. Hartinger, A. Loidl, A.A. Mukhin, V.Yu. Ivanov, and A.M.Balbashov
"METALLIC CONTRA HOPPING CONDUCTIVITY IN $La_{1-X}Sa_XMnO_3$ FOR $x \approx 0.175$"

10.45-11.00 **Th-OB04**
H.R. Khan and K. Petrikowski
"INFLUENCE OF MAGNETIC FIELD ON THE D.C. AND A.C. ELECTRODEPOSITION OF COBALT"

Coffee break

INVITED LECTURE

11.30-12.00 **Th-IB03**
V.V. Tarasenko, **V.G. Baryakhtar**, S.V. Tarasenko (Ukraine)
"SUPERCRITICAL DYNAMICS OF A DOMAIN WALL IN ULTRATHIN FERROMAGNETIC FILM"

Oral presentations

12.00-12.15 **Th-OB05**
A. Perlov, S. Halilov, H. Eschrig
"CALCULATION OF THE LOW LYING MAGNETIC EXCITATIONS WITHIN DENSITY FUNCTIONAL THEORY"

12.15-12.30 **Th-OB06**
J.Y. Rhee, Yu.V. Kudryavtsev, K.W. Kim, and Y.P. Lee
"ELECTRONIC STRUCTURES AND MAGNETIC PROPERTIES OF NEAR-EQUIATOMIC Fe-Ti ALLOYS"

Thursday, June 8, 2000 Section B

12.30-12.45 **Th-OB07**
P.H.R. Barbosa, E.P. Raposo, M.D. Coutinho-Filho
"MONTE CARLO DYNAMICS OF THE SPIN-GLASS BEHAVIOR IN $Fe_{0.25}Zn_{0.75}F_2$"

12.45-13.00 **Th-OB08**
G.A. Petrakovskii, K.S. Aleksandrov, L.N. Bezmaternikh, S.S. Aplesnin, B.Roessli, A. Amato, C. Baines, F. Semadeni, J. Bartolome, M. Evangelisti
"A SPIN GLASS STATE IN $CuGa_2O_4$"

LUNCH

INVITED LECTURES

14.00-14.30 **Th-IB04**
E.A. Turov, A.V. Kolchanov (Russia)
"THE ESSAYS ON DYNAMIC OF MAGNETIC (SPIN) SYSTEMS"

14.30-15.00 **Th-IB05**
D. Stoeffler, C. Cornea, M. Freyss and **H. Dreysse** (France)
"NANOSCOPIC TO MESOSCOPIC MAGNETISM: AN UNIFIED ELECTRONIC PICTURE"

Oral presentations

15.00-15.15 **Th-OB09**
A.E. Krasovskii
"ELECTRONIC STRUCTURE OF Fe-Ni COMPOUNDS AT THE EARTH'S CORE CONDITIONS"

15.15-15.30 **Th-OB10**
S.V. Gorobets, I.A. Melnichuk, O.Yu. Gorobets, Yu. Legenkii, V.I. Mihaylov
"MULTILEVEL PACKINGS FOR MAGNETIC SEPARATORS AND FILTERS FORMED OF MAGNETIC PARTICLES"

15.30-15.45 **Th-OB11**
P.C. Fannin, A. Slawska-Waniewska, S.W. Charles, P. Didukh and P. Perov
"SUSCEPTIBILITY MEASUREMENTS AND NEEL RELAXATION"

15.45-16.00 **Th-OB12**
H. Chiriac, C.S. Marinescu and M. Marinescu
"HARD AND SOFT AMORPHOUS MAGNETIC MATERIALS BASED MICRO ROTARY-ENCODER"

LIST OF INVITED LECTURES AND ORAL PRESENTATIONS

Friday, June 9, 2000 Section A

INVITED LECTURES

9.00-9.30 **Fr-IA01**
J.B. Sousa, G.N. Kakazei, Yu.G. Pogorelov, P.P. Freitas, S. Cardoso, A.M.L.Lopes, M.M. Pereira do Azevedo, J.A.M. Santos, E. Snoeck (Portugal)
"TRANSPORT, MAGNETIC AND TIME DEPENDENT EFFECTS IN METAL-INSULATOR DISCONTINUOUS MATERIALS"

9.30-10.00 **Fr-IA02**
V.F. Los, V.G. Saltanov (Ukraine)
"SPIN-DEPENDENT TRANSPORT IN MAGNETIC MULTILAYERS AND SANDWICHES WITH ACCOUNT FOR AN ELECTRONIC STRUCTURE AND INTERFACE ROUGHNESS"

Oral presentations

10.00-10.15 **Fr-OA01**
M. Inoue, T. Fujii, K.I. Arai and M. Abe
"ONE-DIMENSIONAL MAGNETOPHOTONIC CRYSTAL WITH A THIN RARE-EARTH IRON GARNET FILM"

10.15-10.30 **Fr-OA02**
I.L. Lyubchanskii, N.N. Dadoenkova, M.I. Lyubchanskii, Jae-Woo Jeong, Sung-Chul Shin, and Th. Rasing
"SECOND HARMONIC LIGHT SCATTERING BY DISLOCATIONS IN MAGNETIC CRYSTALS"

10.30-10.45 **Fr-OA03**
P. Allia, M. Coisson, P. Tiberto, F. Vinai
"ON THE HYSTERETIC MAGNETIZATION OF GRANULAR MAGNETIC SYSTEMS AT ROOM TEMPERATURE"

10.45-11.00 **Fr-OA04**
J. Koeble, M. Huth
"INDUCED UNIDIRECTIONAL MAGNETIC ANISOTROPY IN Fe_2Ti THIN FILMS"

Coffee break

INVITED LECTURE

11.30-12.00 **Fr-IA03**
J. Kirschner
"MESOSCOPIC MAGNETS: DOTS, WIRES, AND PILLARS ON THE NANOMETER SCALE"

Oral presentations

12.00-12.15 **Fr-OA05**
Ya.B. Bazaliy, B.A. Jones
"DYNAMIC ANALISIS OF CURRENT INDUCED MAGNETIZATION SWITCHING IN SMALL DOMAINS"

Friday, June 9, 2000 Section A

12.15-12.30 **Fr-OA06**
G. Isella, R. Bertacco, L. Duo and F. Ciccacci
"ELECTRONIC AND MAGNETIC PROPERTIES OF THE OXYGEN ASSISTED GROWN Cr/Fe(001) INTERFACE"

12.30-12.45 **Fr-OA07**
C.de la Fuente, L. Benito, J.I. Arnaudas, M.R. Wells, R.C.C. Ward and A.delMoral
"COMPETING MAGNETIC ANISOTROPIES IN Ho/Tm SUPERLATTICES"

12.45-13.00 **Fr-OA08**
P.S. Clegg, J.P. Goff, R.A. Cowley, G.J. McIntyre, R.C.C. Ward and M.R.Wells
"COMPETING COMMENSURATE AND INCOMMENSURATE MAGNETIC STRUCTURES IN DHCP CE/ND SUPERLATTICES"

LUNCH

INVITED LECTURES

14.00-14.30 **Fr-IA04**
F. Nguyen Van Dau (France)
"DEVELOPMENT OF MAGNETIC NANOSTRUCTURES FOR APPLICATION AS LINEAR MAGNETORESISTIVE SENSORS"

14.30-15.00 **Fr-IA05**
A.N. Pogorily (Ukraine)
"FMR PECULIARITIES IN ULTRATHIN AND GRANULAR FILMS"

Oral presentations

15.00-15.15 **Fr-OA09**
A.B. Drovosekov, N.M. Kreines, D.I. Kholin, V.F. Meshcheryakov, O.V.Zhotikova, M.A. Milyaev, L.N. Romashev, and V.V. Ustinov
"INHOMOGENEOUS FMR MODES IN $[Fe/Cr]_n$ SUPERLATTICES WITH A STRONG BIQUADRATIC COUPLING"

15.15-15.30 **Fr-OA10**
V.A. Ignatchenko, Yu.I. Mankov, A. Maradudin
"SPIN-WAVE SPECTRUM OF MULTILAYERS WITH FINITE THICKNESSES OF INTERFACES"

15.30-15.45 **Fr-OA11**
E. Hasmonay, J. Depeyrot, M.H. Sousa, F.A. Tourinho, J.-C. Bacri, R.Perzynski, Yu.L. Raikher, I. Rosenmann
"MAGNETIC STRUCTURE OF $NiFe_2O_4$ NANOPARTICLES IN FERROFLUIDS"

15.45-16.00 **Fr-OA12**
G.F. Goya, H.R. Rechenberg
"FORMATION OF INTERMETALLIC Al_xFe_{1-x} FROM MECHANICAL ALLOYING OF Al/Fe_2O_3 COMPOSITE"

Friday, June 9, 2000 Section B

INVITED LECTURES

9.00-9.30 **Fr-IB01**
P. Vojtanik (Slovakia)
"MAGNETIC RELAXATIONS AND MAGNETIZATION PROPERTIES OF FERROMAGNETIC ALLOYS"

9.30-10.00 **Fr-IB02**
T. Okuda (Japan)
"PREPARATION, STRUCTURE, AND MAGNETIC AND MAGNETOOPTICAL PROPERTIES OF $Bi_3Fe_5O_{12}$"

Oral presentations

10.00-10.15 **Fr-OB01**
L.M. Garcia, J. Chaboy, F. Bartolome, J. Goedkoop
"ORBITAL MAGNETIC MOMENT INSTABILITY AT THE SPIN REORIENTATION TRANSITION OF $Nd_2Fe_{14}B$"

10.15-10.30 **Fr-OB02**
J.M. Torres Bruna, L.M. Garcia, J. Bartolome, W. Rodewald
"MAGNETIC VISCOSITY STUDY OF THIN FLEXIBLE RE MAGNET-FOILS"

10.30-10.45 **Fr-OB03**
A. Ahmad and I.R. Harris
"PRODUCTION OF $Pr_{16}Fe_{76}B_8$ MAGNETS BY BLENDING WITH COBALT"

10.45-11.00 **Fr-OB04**
Yu.G. Pastushenkov, N.P. Suponev, A.V. Koriakovskij, A. Fork, H.Kronmueller
"THE MAGNETIC DOMAIN STRUCTURE ON THE BASAL PLANE OF $Fe_{14}Nd_2B$ SINGLE CRYSTALS DURING THE SPIN-REORIENTATION TRANSITION"

Coffee break

INVITED LECTURE

11.30-12.00 **Fr-IB03**
Yu.N. Dragoshanskii (Russia)
"DYNAMIC DOMAIN STRUCTURE AND CORE LOSSES BEHAVIOUR IN TEXTURED SOFT MAGNETIC MATERIALS"

Oral presentations

12.00-12.15 **Fr-OB05**
K. Yamaguchi, K. Yamada
"SIMULATION OF SPIN SYSTEM FOR NONDESTRUCTIVE EVALUATIONS OF IRON-BASED MATERIALS"

Friday, June 9, 2000 Section B

12.15-12.30 **Fr-OB06**
L. Shepeleva, V. Manov and Yu. Tarakanov
"MAGNETIC PROPERTIES OF MULTI-PHASE AMORPHOUS AND NANOCRUSTALINE MATERIALS"

12.30-12.45 **Fr-OB07**
A. Lovas, L.F. Kiss, B. Varga, P. Kamasa and L. Pogany
"RELAXATION AND EARLY STAGE OF CRYSTALLIZATION IN NANOCRYSTALLINE PRECURSORS"

12.45-13.00 **Fr-OB08**
S.S Aplesnin
"A STUDY OF ANTIFERROMAGNETIC AND SINGLE STATES IN THE QUASI-ONE DIMENSIONAL HEISENBERG MODEL WITH RANDOM EXCHANGE BONDS WITH S=1/2 BY QUANTUM MONTE CARLO METHOD"

LUNCH

INVITED LECTURES

14.00-14.30 **Fr-IB04**
V.V. Kokorin (Ukraine)
“MAGNETIC FIELD INDUCED STRAINS IN FERROMAGNETIC SHAPE MEMORY ALLOYS”

14.30-15.00 **Fr-IB05**
A. Sozinov, P. Yakovenko, **K. Ullakko** (Finland)
“LARGE MAGNETIC-FIELD-INDUCED STRAINS IN Ni-Mn-Ga ALLOYS DUE TO REDISTRIBUTION OF MARTENSITE VARIANTS”

Oral presentations

15.00-15.15 **Fr-OB09**
G. David, S. Roth, J. Eckert, L. Schultz
"PREPARATION OF RIBBONS OF IRON ALLOYS WITH HIGH Si CONTENT BY MELT SPINNING AND ANNEALING IN HYDROGEN FLOW"

15.15-15.30 **Fr-OB10**
L.K. Powell, I.Z. Rahman and M.A. Rahman
"FABRICATION Ni-Zn-Cu FERRITE POWDERS AND POLYMER PASTES"

15.30-15.45 **Fr-OB11**
Kh.G. Bogdanova, V.A. Golenischev-Kutusov, M.I. Kurkin
"GIANT MAGNETOACOUSTIC EFFECT CAUSED BY NUCLEAR MAGNETISM"

15.45-16.00 **Fr-OB12**
I.S. Tereshina
"EFFECT OF HYDROGEN ON THE MAGNETOCRYSTALLINE ANISOTROPY AND MAGNETIC PHASE TRANSITIONS OF $RFe_{11}Ti$ SINGLE CRYSTALS"

EMMA-2000, June 7-10, 2000, Kyiv, Ukraine
LIST OF INVITED LECTURES AND ORAL PRESENTATIONS
Saturday, June 10, 2000 Section A

INVITED LECTURES

9.00-9.30 **Sa-IA01**
J.-Q. Wang, L.M. Malkinski, J.M. MacLaren and C. J. O'Connor (USA)
"MAGNETORESISTANCE OF THE Co/Cu/Co PSEUDO-SPIN VALVES"

9.30-10.00 **Sa-IA02**
V.V. Eremenko, S.L. Gnatchenko, M. Baran, V.A. Bedarev, R. Szymczak, **H.Szymczak** (Poland)
"EFFECT OF LIGHT ILLUMINATION ON MAGNETIC PHASE TRANSITIONS IN MANGANESE OXIDES"

Oral presentations

10.00-10.15 **Sa-OA01**
H.K. Lachowicz, A. Sienkiewicz, P. Gierlowski and A. Slawska-Waniewska
"FMR - EXPERIMENT IN GRANULAR $Cu_{90}Co_{10}$ MAGNET"

10.15-10.30 **Sa-OA02**
A. Radulescu, U. Ebels, L. Piraux, Y. Henry and K. Ounadjela
"THE ROLE OF SPIN ACCUMULATION IN THE MAGNETORESISTANCE OF A SINGLE DOMAIN WALL"

10.30-10.45 **Sa-OA03**
Yu.G. Pogorelov
"LONG- AND SHORT-RANGE MAGNETIC ORDER IN GRANULAR ARRAYS WITH DIPOLAR COUPLING"

10.45-11.00 **Sa-OA04**
U.K. Rossler
"MONTE CARLO SIMULATIONS FOR MODELS OF DIPOLARLY INTERACTING FINE MAGNETIC PARTICLES"

Coffee Break

EMMA-2000, June 7-10, 2000, Kyiv, Ukraine
LIST OF INVITED LECTURES AND ORAL PRESENTATIONS

Saturday, June 10, 2000 Section B

INVITED LECTURES

9.00-9.30 **Sa-IB01**
V.V. Eremenko, V.A. Sirenko (Ukraine)
"HYSTERESIS AND MAGNETOSTRICTION IN HETEROGENEOUS SYSTEMS AT LOW TEMPERATURES"

9.30-10.00 **Sa-IB02**
V.L. Vvedensky, V.I. Ozhogin (Russia)
"BIOMAGNETISM UPDATE"

10.00-10.30 **Sa-IB03**
N.M. Sergienko (Ukraine)
"MAGNETOREGULATED INTRAOCULAR ARTIFICIAL LENS"

Oral presentations

10.30-10.45 **Sa-OB01**
J. Stankiewicz, J. Bartolome, M. Morales, and D. Fruchart
"ELECTRICAL RESISTIVITY OF $RMn_{12-x}Fe_x$"

10.45-11.00 **Sa-OB02**
G. Matteucci, C. Beeli, E. Bonetti, L. Del Bianco, L. Pasquini
"NANOCRYSTALLINE Fe POWDERS ANALYZED BY ELECTRON HOLOGRAPHY"

Coffee break

Saturday, June 10, 2000 GENERAL SESSION

11.30-12.00 **Sa-IG01**
S. David, **D. Givord** and J.C. Toussaint (France)
"MAGNETISM IN HARD NANOCOMPOSITES"

12.00-12.30 **Sa-IG02**
A.S. Bakai (Ukraine)
"PHASE TRANSFORMATIONS AND PHASE TRANSITIONS IN GLASS-FORMING LIQUIDS AND DISORDERED SPIN SYSTEMS"

12.30-13.00 SaIG03
K.V. Rao, V. Ström, J. Wittborn, C. Canalias, W. Voit (Sweden)
"NOVEL PROBES TO LOCAL MAGNETISM AT SUB-MICRON TO NANOSCALE"

SEMINAR
"Selected topics of dynamics and structure of magnetic materials"
In memorizing of Professor Alex Hubert

Schedule of the seminar
Selected topics on dynamics and structure of magnetic materials

In memorizing of Professor Alex Hubert

	Thursday June 8, 2000	**Friday June 9, 2000**
9.30	Th-S01	Fr-S01
10.00	Th-S02	Fr-S02
10.20	Th-S03	Fr-S03
10.40	Th-S04	Fr-S04
11.00	Coffee break	
11.30	Th-S05	Fr-S05
11.50	Th-S06	Fr-S06
12.10	Th-S07	Fr-S07
12.30	Th-S08	
13.00	Lunch	
15.00	Th-S09	Fr-S08
15.20	Th-S10	Fr-S09
15.40	Th-S11	Fr-S10
16.00	Th-S12	Fr-S11
16.20	Th-S13	Fr-S12
16.40	Th-S14	Fr-S13
17.00		

SEMINAR "Selected topics of dynamics and structure of magnetic materials"

In memorizing of Professor Alex Hubert

Thursday, June 8, 2000

9.30-10.00	**Th-S01** **H. Kronmuller** "ALEX HUBERT: A CREATIVE AND OUTSTANDING SCIENTIST"
10.00-10.20	**Th-S02** **R. Schaefer** "THE ANALYSIS OF HIDDEN MAGNETIC DOMAINS"
10.20-10.40	**Th-S03** I.V.Baryakhtar, **V.G. Baryakhtar**, E.N. Economou "DOMAIN WALL AND BREATHER KINETIC IN FERROPMAGNETS AND ANTIFERROMAGNETS"
10.40-11.00	**Th-S04** **A. Thiaville**, J. Miltat "VERTICAL BLOCH LINE DYNAMICS IN BUBBLE GARNET FILMS"

Coffee Break

11.30-11.50	**Th-S05** **E.D. Belokolos** "SYMMETRY OF DOMAIN STRUCTURES AND DOMAIN BRANCHING IN MAGNETICS AND SUPERCONDUCTORS"
11.50-12.10	**Th-S06** H. Benner, **B. A. Kalinikos**, and N.G. Kovshikov "EXCITATION OF BLACK SPIN WAVE ENVELOPE SOLITONS IN FERROMAGNETIC FILMS"
12.10-12.30	**Th-S07** **G.A. Melkov**, A.N. Olijnyk, A.A. Serga, A.N. Slavin, V.S. Tiberkevich "PHASE CONJUGATION OF LINEAR AND NONLINEAR SIGNALS OF MAGNETOSTATIC WAVES"
12.30-12.50	**Th-S08** **C.E. Zaspel** "HIGH POWER ULTRANARROW SOLITARY WAVES IN MAGNETIC THIN FILMS"

LUNCH

15.00-15.20	**Th-S09** **A.P. Tankeyev**, M.A. Shamsutdinov, A.T. Kharisov "SPIN-REORIENTATIONAL TRANSITIONS AND MAGNETOELASTIC SOLITONS IN EASY-PLANE ANTIFERROMAGNETS"
15.20-15.40	**Th-S10** **A.N. Bogdanov** "MAGNETIC VORTICES IN NONCENTROSYMMETRIC MAGNETIC CRYSTALS"
15.40-16.00	**Th-S11** **D.D. Sheka,** V.M. Muravyov, I.A Yastremsky, B.A. Ivanov "SOLITON - MAGNON SCATTERING AND NORMAL MODES FOR A MAGNETIC PARTICLES IN CIRCULAR GEOMETRY"

SEMINAR "Selected topics of dynamics and structure of magnetic materials"

In memorizing of Professor Alex Hubert

Thursday, June 8, 2000

16.00-16.20 **Th-S12**

O.Yu. Gorobets

"THE EFFECTIVE MASS OF THE THREE - DIMENSIONAL LOCALIZED DISTRIBUTION OF MAGNETIZATION IN FERROMAGNET"

16.20-16.40 **Th-S13**

A.L Sukstanskii, **S.A.Reshetnyak**, V.N.Varyukhin

"SPIN WAVE SPECTRUM AND RELAXATION IN NON-COLLINEAR $CsCuCl_3$ TYPE ANTIFERROMAGNETS"

16.40-17.00 **Th-S14**

O.K. Dudko, A.S. Kovalev

"TOPOLOGICAL MAGNETOSTRUCTURAL SOLITONS IN 2D ANTIFERROMAGNET CONTAINING A DISLOCATION"

EMMA-2000, June 7-10, 2000, Kyiv, Ukraine
SEMINAR "Selected topics of dynamics and structure of magnetic materials"
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Friday, June 9, 2000

9.30-10.00 **Fr-S01**
N.N. Plakida, V.S. Oudovenko
"SPIN-FLUCTUATION SUPERCONDUCTING PAIRING IN STRONGLY CORRELATED METALS"

10.00-10.20 **Fr-S02**
R.A. Istomin, A. S. Moskvin
"OVERLAP FOR QUANTUM SKYRMIONS IN 2D SPIN SYSTEMS"

10.20-10.40 **Fr-S03**
Yu.D. Panov, A. S. Moskvin
"ORBITAL MAGNETIC FLUCTUATIONS IN DOPED CUPRATES"

10.40-11.00 **Fr-S04**
R.O. Kuzian
"SPECTRAL DENSITY OF A HOLE IN FRUSTRATED ONE-DIMENSIONAL ANTIFERROMAGNET"

Coffee break

11.30-11.50 **Fr-S05**
B.A. Ivanov, V.E.Kireev, A.Yu. Merkulov
"SPIN DISCLINATIONS: CLASSICAL AND QUANTUM PROPERTIES"

11.50-12.10 **Fr-S06**
J.J. Alonso, J.F. Fernandez
"INCOHERENT TUNNELING IN A SYSTEM OF INTERACTING MAGNETIC DIPOLES"

12.10-12.30 **Fr-S07**
E. Koshuna, **V. Krivoruchko**
"SUPERCURRENTS THROUGH THE JOSEPHSON π-JUNCTIONS"

LUNCH

15.00-15.20 **Fr-S08**
M. Kenzelmann, R.A.Cowley, W. J. L. Buyers, R. Coldea, S. M. Bennington, J. S. Gardner, D. F. McMorrow
"DISORDERED PHASE OF ANTIFERROMAGNETIC SPIN CHAIN $CsNiCl_3$"

15.20-15.40 **Fr-S09**
Z.V. Popovic, V.A. Ivanova, M. J. Konstantinovic, V.V. Moshchalkov
"PHONON AND SPIN DYNAMICS IN SPIN LADDER CUPRATES AND VANADATES"

15.40-16.00 **Fr-S10**
G. Kamieniarz, **M. Bielinski**, J.-P. Renard
"EXPERIMENTAL AND QUANTUM TRANSFER-MATRIX SIMULATION DATA FOR $CuGeO_3$ SUSCEPTIBILITY"

Friday, June 9, 2000

16.00-16.20 **Fr-S11**
O. Derzhko, **T. Krokhmalskii**, J. Stolze
"TOWARDS THE RELATION BETWEEN ELEMENTARY EXCITATION SPECTRUM AND DYNAMIC STRUCTURE FACTOR: EXACT ANALYSIS FOR THE SPIN-1/2 XX CHAIN"

16.20-16.40 **Fr-S12**
A.K. Kolezhuk
"QUANTUM CHIRAL PHASES IN FRUSTRATED SPIN CHAINS"

16.40-17.00 **Fr-S13**
A.S. Kovalev, S. Komineas, F.G. Mertens
"2D NONLINEAR EXCITATIONS IN EASY-PLANE FERROMAGNETS: SOLITONS AND VORTICES"

Wednesday, June 7, 2000

Wednesday, June 7, 2000
General Session

We-IG01
MAGNETIC FIELD EFFECTS IN ELECTRODEPOSITION

J.M.D. Coey, G. Hinds and T.R. Ní Mhíocháin
Trinity College, Dublin 2, Ireland.

Magnetic fields are found to influence the rate of electrodeposition and the form of the electrodeposit when non-magnetic or magnetic metals are deposited from solution. They can also be used to control convection in conducting melts from which crystals are grown by the Bridgman or Czockralski methods, and there are reports that nucleation and growth of crystals from saturated solutions are also influenced by a magnetic field. Recent work in these areas will be reviewed, and the mechanisms by which the magnetic field could influence these phenomena are discussed. Dimensional analysis is used to assess the relative magnitudes of the possible effects.

We-IG02
MAGNETIC EXCITATION WITH SPIN-POLARIZED CURRENT

J.C. Slonczewski
IBM Watson Research Center
Box 218, Yorktown Heights, NY 10598, USA

Four years ago, L. Berger [1] predicted one-dimensional spin-wave excitation while the author predicted domain reversal [2], both effects due to the exchange field created by a spin-polarized current. Recent experiments use either a mechanical point contact [3], a tiny magnetic particle [4], or electron-beam lithography [5,6] to create the narrow distribution of plane-perpendicular current needed for such effects. The observed current-voltage anomalies provide evidence for excitation of two-dimensional spin waves [3,5] and domain reversal [4,5,6].
A macroscopic theory [2,7] relies on conservation of spin momentum to establish the existence of exchange-driven torque vectors lying within the instantaneous plane formed by two adjoining ferromagnetic moments. Thus the excitation process is governed by mutual coupling of 1) the Landau-Lifshitz equation, 2) Kirchhoff's laws for a network of voltages and charge currents usually flowing perpendicular to the film plane, 3) a 3-component diffusion equation for a spin-density vector in the corresponding spin-channel network, and 4) Berger's Josephson-like frequency-proportional potential reacting from the magnetic precession. Solutions of these equations illuminate interesting and potentially useful exchange-driven phenomena.

[1] L. Berger, Phys. Rev. B **54**, 9353 (1996). [2] J. C. Slonczewski, J. Magn. Magn. Mater. **159**, L1 (1996). [3] M. V. Tsoi, et al, Phys. Rev. Lett. **80,** 4281 (1998). [4] J. Sun, J. Magn. Magn. Mater. **202**, 157 (1999). [5] E. B. Myers, et al, *Science* **283**, 867 (1999). [6] J. A. Katine, et al, unpublished. [7] J. C. Slonczewski, J. Magn. Magn. Mater. **195,** L261 (1999).

Wednesday, June 7, 2000
General Session

We-IG03
SPIN POLARIZED TUNNELING

Jagadeesh S. Moodera
Francis Bitter Magnet Laboratory,
Massachusetts Institute of Technology, Cambridge, MA 02139 USA

Tunneling phenomenon has enriched our understanding of various branches of physics over the years. Spin-polarized tunneling discovered by Meservey and Tedrow showed that tunneling electrons coming from a ferromagnet are spin-polarized and spin is conserved in this process. Many of these studies are yet to be theoretically explained. The basics of spin polarized tunneling and particularly the current hot topic ferromagnetic - insulator - ferromagnetic tunneling including some of the challenges will be described.
Large junction magnetoresistance (JMR) at room temperature and in a low applied magnetic field is seen with transition metal ferromagnets. There has been great progress in this area in the past four years both from the point of view of fundamental physics as well as technological application. Topics that will be covered briefly include the basics, observation of quantum well states, enhanced JMR effects due to modified barriers, how FM-I-FM structure can be used to investigate half-metallic ferromagnets and other fundamental phenomena based on spin tunneling. For instance, the study of magnetic interaction in rare earth metal ions and layers has shown novel effects. The magnetic tunnel junctions show nonvolatile memory effect, ideally suited for MRAM applications. JMR sensors have high sensitivity factors and when used as read heads can achieve magnetic storage densities greater than 100 Gb/in^2.

We-IA01

LOW FIELD MAGNETORESISTANCE IN PEROVSKITE STRUCTURE MANGANITES

H.R. Khan
FEM, Materials Physics Department, Schwaebisch Gmuend, Germany and Department of Physics, University of Tennessee Knoxville, TN. U.S.A.

Some doped simple and double perovskite structure manganites show colossal magnetoresistance (CMR) in the vicinity of Curie-temperature (T_c) by the application of high magnetic fields of the order of Tesla or more.This CMR is related to the magnetic ordering in these materials. Polycrystalline bulk and films of these materials also show a magnetoresistance in low magnetic fields of the order of mT (LFMR) and in a whole temperature range below T_c. This LFMR is caused by the spin polarized tunneling between the ferromagnetic grains through the grain boundary barriers and is of great potential for the applications. Experimental research of LFMR in simple and double perovskite structure manganites is reviewed and models to explain this effect are described. In order to improve and understand LFMR, the grain boundaries must be modified. In a recent experimental work we decorated the grain boundaries of a polycrystalline simple perovskite structure $La_{0.5}Pb_{0.5}MnO_3$ manganite with a T_c value around room temperature with mono-, di- and trivalent metals e.g. Ag^{1+}, Zn^{2+}, Au^{3+}, In^{3+}...
Magnetic field and temperature dependent MR measurements show large and different LFMR amplitudes depending on the type of grain boundary decoration in these materials. These data show the effect of grain boundary structure on the LFMR in polycrystalline manganites. Relationship of the LFMR originating from the grain boundaries in these materials with the magnetic structure, crystallographic structure and electrical resistivity is investigated.

We-IA02

HIGH-FREQUENCY ANALOGUES OF GIANT MAGNETORESISTANCE IN MAGNETIC SUPERLATTICES

V.V. Ustinov, A.B. Rinkevich, L.N. Romashev
Institute of Metal Physics, Ural Division of RAS,
18 S. Kovalevskaya St., Ekaterinburg, 620219, Russia

The physical properties of metallic multilayers, especially giant magnetoresistance (GMR) effect, were intensively investigated during the last decade. As a rule, GMR measurements are performed with a *dc* current in the 'current-in-plane' (CIP) geometry or in the 'current-perpendicular-to-plane' (CPP) geometry. Only a limited number of investigations were devoted to the studies of microwave (MW) electromagnetic properties of metallic multilayers. The results of CIP and CPP microwave experiments are reported in the present work.
It is demonstrated that magnetic field dependence of microwave absorption in Fe/Cr/Fe epitaxial sandwiches is defined by the giant magnetoresistive effect. The direct correlation between GMR and transmission of electromagnetic waves through Fe/Cr superlattices is established. These experiments were performed in the 'current-in-plane' (CIP) geometry because the microwave eddy currents were in the plane of the layers.
A new simple method of CPP MW–magnetoresistance measurement is demonstrated. The absorption of high frequency electromagnetic waves by a multilayer in the special geometry of our MW experiment was investigated. The sample was placed inside the MW cavity in the maximum of electric field in such a way that the MW electric field was aligned perpendicular to the plane of the layers. Thus the CPP geometry for microwave GMR measurements was simply realized.
The theory describing MW CIP and MW CPP GMR is developed.
The work is supported by RFBR grants №98-02-17553 and №98-02-17517.

Wednesday, June 7, 2000
Section A

We-IA03
MAGNETIC PROPERTIES OF SMALL FERROMAGNETIC PARTICLES OF THE VARIOUS SYMMETRY

A.P. Shpak, A.B. Shevchenko*, A.B. Melnik
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36 Academician Vernadsky Blvd., 03142 Kyiv, Ukraine
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Magnetic properties of small ferromagnetic particles has been the subject of intensive studies due to the great potential of their practical application [1]. Among those particles there is particular interest in clusters, i.e., small particles which consist of finite number of atoms. Both numerical calculations using of the Lennard-Jones potential [2] and numerous experiments have corroborated the possibility of existence (side by side with f.c.c. and b.c.c. clusters) of icosahedral-shaped clusters with the axis of 5-fold symmetry forbidden by the translation symmetry for crystal bulk solids. The influence of the symmetry on the magnetic properties of the clusters has been investigated. It is shown that the 5-fold symmetry axis is the axis of easy magnetization icosahedral-shaped clusters. The energy of the magnetic anisotropy as a function of the number *N* of atoms in the clusters of various symmetry has been obtained. The magnetization of clusters with the various orientation magnetic fields has been investigated. The cluster coercive force has been evaluated.

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We-OA01
EFFECT OF Mn-SUBSTITUTION WITH Zn, Cu, Co, Cr, Al, Ti, Nb ON MAGNETIC AND TRANSPORT PROPERTIES OF $La_{0.7}Sr_{0.3}(Mn_{1-x}Me_x)O_3$

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The interplay between magnetism and electrical transport in $Ln_{1-x}Sr_xMnO_3$ (Ln=lanthanide) manganites could be explained on the base of study of Mn - substituted series $La_{0.7}Sr_{0.3}(Mn_{1-x}Me_x)O_3$ (Me=Zn^{2+}, Cu^{2+}, Co^{2+}, Cr^{3+}, Al^{3+}, Ti^{4+}, Nb^{5+}). The studied samples were prepared as both single crystals and ceramics. The Mn substitution with Zn, Cu and Co leads to Mn^{3+} transformation into Mn^{4+} whereas that with Nb converts Mn^{4+} into Mn^{3+}. All these substitutions are shown to decrease the Curie point as well as destroy the ferromagnetic order. From the concentrational dependencies of spontaneous magnetization the collapse of the long range ferromagnetic order is found to be at the following doping levels: x=0.25 (Me=Zn, Cu, Ti); x=0.3 (Me=Co, Al) and x=0.5 (Me=Cr). $La_{0.7}Sr_{0.3}Mn^{3+}_{0.85}Nb^{5+}_{0.15}O_3$ exhibits the ferromagnetic order and large magnetoresistance at 130 K despite the absence of Mn^{3+}/Mn^{4+} pairs. Superexchange Mn^{3+}-O-Mn^{3+} interaction is ferromagnetic. The magnetoresistance effect is more pronounced near the concentrational ferromagnet - spin glass transition. We suggest that an external magnetic field stabilizes the ferromagnetic order more effectively for the compounds near the concentrational phase transition boundary.

We-OA02

MAGNETO-TRANSPORT AND HALL EFFECT IN Sr_2FeMoO_6 THIN FILMS

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Recently, a large negative magnetoresistance was revealed in the ferro(i)magnetic double-perovskite Sr_2FeMoO_6 [1]. These oxides are, as the mixed-valence manganites, half-metallic materials, but with a higher Curie-temperature of 410 - 450 K. Therefore a considerable spin-polarisation remains at room temperature which can be exploited for applications.
We prepared epitaxial thin Sr_2FeMoO_6 films on $SrTiO_3$ (100) substrates by pulsed laser deposition. With X-ray diffraction we investigated the crystallographic properties. The compounds are (00*l*) oriented with a large variation of the c-axis length. Deposition at higher temperatures releases epitaxial strain due to the substrate. A high degree of epitaxy reflects in narrow rocking curves of 0.04° width. Deposition in an oxygen partial pressure leads to polycrystalline yellow insulators, whereas deposition at very low pressures or in Ar atmosphere results in epitaxial black samples. The stoichiometry was checked by Rutherford backscattering. Depending on preparation conditions semiconducting or metallic behaviour was found. Only at high deposition temperatures of 930°C films are metallic with a negative magnetoresistance up to room temperature. For the semiconducting samples, an electronlike ordinary Hall effect and a holelike anomalous Hall contribution is visible. Both coefficients have reversed sign compared to the colossal magnetoresistive manganites.

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We-OA03

LOCALIZED AND DELOCALIZED STATES IN OPTICAL SPECTRA OF LANTHANUM MANGANITES

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Optical, electrical and magnetic properties of lanthanum manganites $La_{1-\delta}MnO_3$ and $La_{0.9}Sr_{0.1}MnO_3$ single crystals have been studied to find out the microscopic origin of phase separation in these materials. $La_{1-\delta}MnO_3$ is dominantly antiferromagnet, $La_{0.9}Sr_{0.1}MnO_3$ is ferromagnet mainly. Two bands in absorption spectra at 0.14 eV and 0.35 eV with strong dependence from magnetic ordering were revealed. Different temperature dependence of resistivity (semiconductor-like) and light transmission (metal-like) below Curie temperature gives evidence for phase separation. Metal-insulator transition takes place in separate regions of insulate matrix. Particularities of properties and the origin of phase separation are explained by the model of the polar (holes $[MnO_6^{8-}]_{JT}$ and electron $[MnO_6^{10-}]_{JT}$) pseudo Jan-Teller clusters formed charge heterogeneity centers [1]. Revealed absorption bands are connected with the transitions in polar clusters (localized states). Drude-like absorption contribution under wavelength increasing is connected with tunnel conductivity in charge heterogeneity centers (delocalized states).
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We-OA04

TUNING MAGNETOTRANSPORT AND MAGNETIC PROPERTIES OF $La_{2/3}Ca_{1/3}MnO_3$ THIN FILMS USING EPITAXIAL STRAIN

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Thin films of manganese perovskite $La_{2/3}Ca_{1/3}MnO_3$ were grown epitaxially on lattice matched (1%) $SrTiO_3$(001) and lattice mismatched (9%) MgO (001) substrates using the pulsed laser deposition method. Film thickness was varied in the range 10 nm to 200 nm. All the films were characterised using X-ray diffraction (crystallographic structure and lattice distortions), AFM (topography), EDX (stoichiometry), magnetisation and magnetotransport measurements in the temperature and field ranges of 1-300 K and 0-7 T, in order to study and understand the different behaviours. Large changes in the ferromagnetic-paramagnetic transition temperature, T_C, and the metal-insulator transition temperature, T_m, have been observed for a change in film thickness. However, no change in stoichiometry could be measured to justify these observations. On the basis of the structural analysis, we conclude that the distortions induced by the lattice mismatch are responsible for the drop in T_C with decreasing thickness (reduction of the Mn-O-Mn angle). The reduction of this angle, which is the key parameter controlling the double exchange interaction, causes the reduction of the bandwidth leading to canted magnetic structures, which reduce the saturation magnetisation in very thin films. A strong in-plane magneto-crystalline (MC) anisotropy is induced by the epitaxial strain and we propose a model which relates the structural change to the modifications in MC anisotropy and magneto transport properties.

Wednesday, June 7, 2000
Section B

We-IB01
COERCIVITY AND COERCIVITY MECHANISMS OF NANOCRYSTALLINE PERMANENT MAGNETS

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The hysteresis loops of nanocrystalline permanent magnets (pms) produced by the melt-spin technique have been investigated for compositions based on the intermetallic compounds $R_2Fe_{14}B$ (R = Nd, Pr), $Sm_2Fe_{14-x}Ga_xC_y$ and Sm_2Co_{17}. The following three types of pms have been studied:
(i) High-coercivity pm with exchange decoupled grains. (ii) High-remanence exchange-spring pms. (iii) High-coercive–high-remanence composite pms with exchange coupled soft and hard magnetic grains.
The temperature dependence of the coercive field, $\mu_0 H_C$, for all three types of magnets obeys a relation for a modified nucleation field, $H_C = \left(2K_1 / \mu_0 M_S\right)\alpha - N_{\mathrm{eff}} M_S$ (K_1 = first anisotropy constant, M_S = spontaneous magnetization). For the analysis of the microstructural parameters α and N_{eff} as obtained for the three types of pms, computational micromagnetism using the Finite Element Method is applied. In particular the role of grain size, grain boundaries, texture of easy axes and the effect of soft magnetic phases will be discussed. From these results general rules for the development of optimized pms with large remanences and large coercivities are derived

We-IB02
DEVELOPMENT OF RECENT PERPENDICULAR MAGNETIC RECORDING MEDIA

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In harmony with dramatic increase of recording area density in hard disk systems, recording media developments has also been accelerated, showing thermal relaxation problems in the recorded signal. A hopeful countermeasure on this is to develop a high anisotropy perpendicular media, which are expected to be thermally stable with high recording resolution. A Co-Cr system alloy has been recently modified so as to show a high perpendicular anisotropy and a high squareness of the M-H loop by adding Nb and Pt, resulting in a low noise medium of finer domain size less than 80nm. Setting appropriate soft magnetic underlayer, the media showed potential for a high density beyond 50Gbits/inch^2 with 0.14 micron track width and a linear density of 400 kFCI. For further high storage density up to 1Terabits/inch2, Fe-Pt composite media have also been proposed. They showed an ideal square loop with an extremely high anisotropy field over 40kOe, suggesting a high thermal stability with a high recording resolution. A clear recorded signal patterns over 500 kFCI has been successfully observed by MFM for even very thin Fe-Pt layers of 12nm. A multilayer of Co/Pd has been also investigated as for a medium. The preparation, compositions, magnetization reversals, thermal stability, and recording performances of these media will be reviewed in terms of the possibility of magnetic storage in the future information society.

Wednesday, June 7, 2000
Section B

We-IB03
A SCENARIO FOR FUTURE INFORMATION STORAGE SYSTEMS

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The demands of modern communication systems have generated an ever increasing need to store digital information. This has fuelled a need for new information storage systems at all levels from the random access computer memory (RAM) to magnetic and optical disc systems. It is becoming clear that magnetics - based memories are set to dominate future information storage systems for reasons of cost and flexibility.
This paper describes the state of the art in present information systems which depend on magnetism in some way as the storage medium. Some indications are given in the future challenges in the technology as relate to high moment, high coercivity and high frequency magnetic materials. In particular, perpendicular recording will be reviewed as a candidate for storing information in future high density disk drives. Nanoscale tracking control will be required and there will be a need for very high data rate parallel systems to cope with downloading large amounts of image data. Optical storage will operate below the diffraction limit. Present semiconductor random access memories will be challenged by magnetic spin - tunneling memories which can switch in less than one nanosecond.
These perceived future trends will require considerable technical advances to challenge magnetic materials scientists and storage system designers in the future.

We-OB01
NUMERICAL MODELING OF WAVE FRONT REVERSAL FOR TWO-DIMENSIONAL SPIN WAVE PACKETS IN MAGNETIC FILMS

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It was shown in [1], that a three-wave (first order) parametric interaction of pulse of backward volume magnetostatic wave (BVMSW) with localized non-stationary microwave pumping in a tangentially magnetized yttrium-iron garnet (YIG) film leads to the propagating pulse amplification , and to the generation of an additional contra-propagating wave pulse with reversed wave front and conjugated phase. This effect was observed in quasi-one-dimensional (1D) spin waveguides (narrow strips of YIG films), and was described theoretically in a 1D model [1]. A *two-dimensional* (*2D)* model of a wave front reversal process for the case of BVMSW is developed in the present work. Dispersion and diffraction of a propagating 2D wave packet and four-wave nonlinearity, that leads to the formation of *solitons* in the 1D case, and *bullets* in the 2D case (see [2]) are taken into account, in distinction to 1D model [1]. Numerical calculations of the wave front reversal process are performed in both 1D and 2D cases.

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We-OB02

MAGNETOELASTIC MECHANISM OF THE MAGNETIC INTERACTION IN THE MAGNETIC/NONMAGNETIC MULTYLAYERS

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Multylayered structures consisting of the alternative magnetic (antiferromagnetic) and nonmagnetic layers frequently show the long range magnetic ordering even for rather thick spacer distances (up to50 A). Moreover, the magnetic spectra point to the presence of the collective magnon modes propagating through the nonmagnetic layers as well. The present paper is aimed at the interpretation of the coupling of the separated magnetic layers based on the magnetoelastic mechanism.

In the ideal lattice the magnetic layers are elastically related with the adjacent nonmagnetic spacers due to compatibility conditions. So, magnetostriction of one magnetically ordered layer produces the strain filed of the same symmetry in the next magnetic layer via the spacer. Such an induced anisotropy favors the parallel orientation of the magnetic moments in all the layers. The value of the induced field is proportional to the magnetostriction constant and it decreases with an increase of the spacer thickness. An additional contribution to the induced anisotropy results from the strains produced by the lattice misfit on the boundaries of different layers.

The same mechanism provides the propagation of the magnetic excitations through the nonmagnetic spacers. The analysis of spectra show strong magnon-phonon coupling and Bragg scattering for the wavelength close to the superlattice period. These effects should reveal themselves in additional peaks in the state density curve for magnetic and elastic excitations.

We-OB03

MICROWAVE FOLDOVER AND BISTABILITY IN NONLINEAR FERROMAGNETIC RESONANCE

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Microwave foldover [1] and recently observed bistability [2] in nonlinear ferromagnetic resonance (FMR) have been investigated experimentally and discussed in detail. Measurements were carried out using yttrium-iron-garnet (YIG) 5-100 μm thick film resonators magnetized normally to the film plane, in the 4-6 GHz band at powers up to +25 dBm. The foldover in the resonator frequency response was observed under fixed power condition and the bistability loops were observed at power sweeping under fixed frequency and field conditions. Pulsed measurements showed that foldover and bistability for YIG films thinner 10 μm arise due to intrinsic nonlinearity of the FMR while they are due to the sample heating for thicker films. Experimental data are described quantitatively using low-power parameters of the FMR response, measured power dependent shift of the resonator frequency, and modified phenomenological theory of bistability. Possible applications of bistable YIG film resonators include microwave modulators and limiters, which are controlled through the application of microwave signal.

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We-OB04

FORMATION OF THE DIRECTED FLOWS IN SOLUTIONS OF ACIDS AND SALTS IN THE VICINITY OF HIGH GRADIENT FERROMAGNETIC PACKING IN A CONSTANT MAGNETIC FIELD

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The influence of high gradient magnetic field created by ferromagnetic packings of various shapes placed into a constant magnetic field on solutions of salts and acids was investigated in the given work. The carried out experiments have shown that packings the directed flows of a liquid are formed in the vicinity of elements of high gradient ferromagnetic packings for a number of solutions of salts ($LaBr_3$, NaCl) and acids (hydrochloric acid HCl, nitric acid HNO_3 etc.). The nonferromagnetic fine-grained particles including microorganisms were used as indicators of movement of liquids (solutions of salts and acids). The assumption is made that the major factors determining formation of directed flows in liquid near the high gradient ferromagnetic packings are the presence of the certain concentration of ions in liquid, conductivity and other characteristics of surface of packing and also the value of gradient of magnetic field in the vicinity of the high gradient packing.

We-PA001

FERROMAGNETIC RESONANCE IN Sr CONTAINED MANGANITE AT CURIE TEMPERATURE

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We have studied ferromagnetic resonance and antiresonance in manganites $La_{0.8}Sr_{0.2}MnO_3$ and $La_{0.7}Sr_{0.3}MnO_3$ in temperature range around Curie Temperature at frequency 10GHz and 20GHz. The temperature and field dependencies of sample magnetization were measured too. As a result we have estimated the parameters of magnetic system of the samples. The behavior of line shape and position of ferromagnetic resonance and antiresonance will be discussed.

We-PA002

CURRENT SWITCHING OF RESISTIVE STATES OF NORMAL METAL - MANGANITE SINGLE CRYSTAL POINT-CONTACT.

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Manganese oxide exhibit a large change in electric resistance in response to a magnetic field- so called colossal magnetoresistance. We have observed polarity dependent reversible effects of applied electric field on the point-contact resistance of $La_{0.2}$ $Sr_{0.8}$ Mn O_3 single crystal -normal metal junctions. The transport of a current through boundary shows hysteretic behavior that testifies to a phase separation of this boundary on conducting ferromagnetic and dielectric antiferromagnetic phases.

We-PA003

MAGNETIC RESONANCE SPECTRA OF THE TWO-PHASE STATE IN $(La_{1-x}Eu_x)_{0.7}Pb_{0.3}MnO_3$ SINGLE CRYSTALS

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Magnetic resonance spectra of the $(La_{1-x}Eu_x)_{0.7}Pb_{0.3}MnO_3$ single crystals with x=0-0.3 has been investigated over a range of temperatures. The measurements were performed using 1) a conventional cavity perturbation technique at ν=10 GHz and 2) a spectrometer operating in ν=37-77 GHz frequency range with a pulsed external magnetic field (H_0). The variation of the Eu content changes the Curie temperature T_C of the crystals from 360 (for x=0) to 150 K (for x=0.5). On the other hand all crystals exhibit the giant magnetoresistance (MR) around T_C and the MR value is almost independent of x. Below T_C over the wide temperature region we observed two absorption lines in the magnetic resonance spectra of all studied samples. Their behavior suggests the two-phase magnetic state of the materials. The frequency-field dependencies of the spectra allow to conclude that these phases are the paramagnetic (PM) and the ferromagnetic (FM) ones. The spectra show the strong dependence on the microwave frequency ν. The rapid increase in the intensity of the line associated with FM phase is observed when ν is increased (and H_0 accordingly too) while the PM line rapidly decreases. Such sensitivity of the two-phase state to the magnetic field suggests that the mechanism of the electronic phase separation occur in this case. Note that the magnetic resonance parameters have the features at the temperatures at which MR shows a maximum. These results indicate that the hetero-phase state plays a dominant role in the giant MR effect.

We-PA004

PHASE SEGREGATION IN La-Pr-MANGANITES UNDER MAGNETIC FIELD

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The magnetic field dependence of the magnetization M and resistivity ρ of the mixed valence manganite $(La_{0.25}Pr_{0.75})_{0.7}Ca_{0.3}MnO_3$ is studied for samples containing both the ^{16}O and ^{18}O. The behavior of $M(H)$ and $\rho(H)$ in both type of samples is characterized by the 'shifted hysteresis' loops and by the marked slow relaxation on some parts of the loop. The effects observed are interpreted in the frame of the model taking into account a coexistence of regions of a ferromagnetic metal and antiferromagnetic dielectric in samples and their evolution under an external magnetic field. The shifted hysteresis is explained in this picture by the progressive increase of the fraction of the ferromagnetic phase. Consequently, the conductivity and presumably also other properties have percolation nature. The isotope composition dependence of the observed effects is in accordance with the known modification of other properties of this system and demonstrates the importance of electron-lattice coupling in manganites.

We-PA005

THE EFFECT OF MAGNETIC FIELD ON THE MAGNETIC STATE FOR $La_{1-x}Ca_xMnO_3$.

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The magnetic properties of $La_{1-x}Ca_xMnO_3$ solid solutions ($0 \le x \le 1$) were measured at temperatures T=2K-600K in fields H=10 Oe-50 kOe. The substitution of La^{3+} ions by Ca^{2+} ions in $LaMnO_3$ (x<0.4) leads to increase of conductivity and appearance of ferromagnetic order. The $La_{1-x}Ca_xMnO_3$ compounds with $0.6 \le x \le 0.9$ cause the most interest. For these compounds the temperature dependences of magnetization at small field are typical for ferromagnetic with $T_c \sim 100K$. However the maximum of magnetization in M(T)-dependences appears above T_c at large fields ($H \ge 5$ kOe). We suppose that this maximum is connected with Neel temperature T_N. The increase of Ca contents from x=0.6 to x=0.9 leads to shift of Neel temperature in the region of smaller temperatures, and increase of magnetic field shifted the position of magnetization maximum into the region of higher temperatures. The simultaneous manifestation of ferromagnetic and antiferromagnetic properties with clear pronounced Neel and Curie temperatures confirms coexistence of two phases - ferromagnetic and antiferromagnetic [1]. The magnetic properties of $La_{1-x}Ca_xMnO_3$ system are explained by indirect exchange and phase separation model [2]. This work was supported by grant INTAS-97-30253

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We-PA006

PHASE SEPARATION IN $La_{0.6}Pb_{0.4}Mn_{0.86}Ni_{0.14}O_3$ MANGANITE

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Temperature dependence of NMR on ^{55}Mn nuclei, magnetization and resistivity have been studied in $La_{0.6}Pb_{0.4}Mn_{0.86}Ni_{0.14}O_3$ (T_C = 242 K) single crystal. Complex NMR spectra, containing separate Mn^{3+} and Mn^{4+} lines as well as motionally narrowed line ($Mn^{(3+\delta)+}$), were observed at 61 K. Due to the increasing rate of the electron holes hopping this spectrum transforms to a single line for T > 195 K. No corresponding anomaly of the resistivity was observed, however, indicating a broad distribution of the hopping rates. Below 160 K the temperature dependence of NMR frequency and the magnetization have the same form as expected for single-phase ferromagnet. For T > 160 K, however, the magnetization decreases much faster compared with the decrease of NMR frequency, which is proportional to the local magnetic moment. The comparison of NMR and magnetization data reveals that phase separation to ferromagnetic and paramagnetic regions occurs. In the broad temperature interval 160-242 K two phases coexist. When approaching T_C, the volume of the paramagnetic areas gradually increases giving rise to an increase of electrical resistivity and magnetoresistance.

We-PA007

MAGNETIC AND TRANSPORT PROPERTIES OF SAMARIUM MANGANITES: EVIDENCE OF TWO PHASE COEXISTENCE IN PARAMAGNETIC STATE

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We study ac susceptibility (χ), second harmonic of magnetization (M_2) in parallel ac and dc magnetic fields and resistivity of $Sm_{1-x}Sr_xMnO_3$ ($x = 0.25; 0.3; 0.4$). According to $\chi(T)$ and $\rho(T)$ data, the manganites exhibit transition from an insulating paramagnetic state to a state with a ferromagnetic moment at T_c which is insulating for $x = 0.25$ ($T_c \approx 100$ K), whereas it is metallic for $x = 0.3$ ($T_c \approx 130$K) and $x = 0.4$ ($T_c \approx 120$K). Above T_c (up to 300K) $\chi(T)$ dependence changes dramatically with x, but $\chi(x,T)$ values are close near T_c . The compounds with x=0.3; 0.4 reveal CMR properties. M_2 shows a field hysteresis in the paramagnetic region (below $T \approx 180$K for x=0.25, 0.3 and $T \approx 160$K for x=0.4) in a weak steady H<300 Oe with $M_2 \neq 0$ at H=0. The last peculiarity means that the samples possess a weak spontaneous magnetization. This effect can be attributed to a new magnetic phase, which is most likely to be the same metallic one, since: (i) values of $ReM_2(T)$ are close in all the manganites at T > 150K whereas their $\chi(T)$ differ from each other by several orders of magnitude; (ii) $M_2(T)$ changes monotonously with x at T < 150K in contrast to $\chi(x,T)$ behavior. Thus, the results indicate the presence of the macroscopic ferromagnetic (metallic) regions above T_c sandwiched by a paramagnetic (insulating) phase that may be due to a phase separation (PS). This observation supports an assumption on ultimate relation between PS and the phase transitions as well as CMR in these compounds.

We-PA008

MAGNETIC STRUCTURE AND COLOSSAL MAGNETORESISTANCE EFFECTS IN $Fe_{0.29}Mn_{0.71}S$ MAGNETIC SEMICONDUCTOR

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The data of structural, magnetic, electric and magnetoresistance investigations of the $Fe_{0.29}Mn_{0.71}S$ sulphide in the range of 4.2-300K and magnetic field up to 50 kOe are presented. The experimental data obtained from the investigations of magnetoresistance show that the ferromagnetic sample $Fe_{0.29}Mn_{0.71}S$ has colossal negative magnetoresistance effect (CMR). The negative CMR effect increases with temperature decreasing and it reaches maximum value $\delta_H=(\rho_H-\rho_0)/\rho_H= -83\%$ at 160K and H=10kOe. Below ~ 150K in the range of structural distortion the magnetoresistance δ_H becomes positive and approaches to value of ~60% for H=5 kOe and ~20% for H=10 kOe at T=90K. With further temperature decreasing the positive magnetoresistance effect falls down and near 77K it becomes negative again. With increasing of the magnetic field (up to 50 kOe) the maximum of negative magnetoresistance is shifted in area of low temperatures (~75K). X-ray analysis shows that $Fe_{0.29}Mn_{0.71}S$ has the NaCl structure with **a**=5.185Å. With decreasing temperature NaCl lattice of sample undergoes the structure transition at Ts=147K. Below Ts the lattice parameter increases. The experimental results on the physical properties of the sulfides $Fe_XMn_{1-X}S$, such as calculations of the magnetic phase diagram, measurements of the magnetization in weak (up to 100 Oe) and strong (up to 20 kOe) fields suggest that a possible mechanism for CMR in the magnetic semiconductor $Fe_{0.29}Mn_{0.71}S$ could be magnetic and electronic phase separation.

We-PA009

CRYSTAL STRUCTURE AND TRANSPORT PROPERTIES OF EPITAXIAL $La_{0.5}Sr_{0.5}CoO_3$ FILMS

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$La_{0.5}Sr_{0.5}Co_3$ thin films have been deposited by laser ablation on the $SrTiO_3(100)$ substrate at 840 – 870^{0}C. X-ray diffraction analyses showed that all the samples have a *c*-axis texture with a misorientation angles less than 1^0 and an in-plane epitaxial relationship between film and substrate [001]LSCO//[001]STO. The $La_{0.5}Sr_{0.5}Co_3$ films have a pseudocubic (perovskite) crystal structure with a lattice constant of $a = 0.3834$ nm. The resistance measurements were carried out by using the four-point-probe method in a temperature range of 4.2 - 300 K. The obtained films have a low residual resistivity, $\rho_0 = 220 – 260\ \mu\Omega$ cm, and show obviously a metallic-like $\rho(T)$ behavior. However, the following analysis reveals that the resistivity at high temperatures is grown to a saturation and $\rho(T)$ at low temperatures turns out to have a more complicated shape than a simple power law. It was shown that unusual behavior of $\rho(T)$ in $La_{0.5}Sr_{0.5}CoO_3$ is induced by the temperature-dependent transition between high- and low-spin states of the Co^{3+} ions.

We-PA010

MAGNETIC, RESISTANCE AND CRYSTALLINE-CHEMICAL PECULIARITIES OF $(La_{0.7}Ca_{0.3})_{1-x}Mn_{1+x}O_3$ MANGANESE-LANTHANUM PEROVSKITES

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$(La_{0.7}Ca_{0.3})_{1-x}Mn_{1+x}O_3$ ceramic samples were investigated by X-rays, magnetic, resistance and NMR methods. It was established with x increasing from 0 up to 0.3 the magnetoresistance ($\Delta R/R_0$) was increased to 1.5 times without marked changing temperature of metal—semiconductor (T_{Rmax}=273 K), ferro—paramagnetic (T_c=277 K) phase transitions and $\Delta R/R_0$ peak (T_p=268 K). ^{55}Mn NMR frequencies stability (f≈374.5 MHz) testifies about constancy of ratio of Mn^{3+}:Mn^{4+} placed in octapositions, taking part in high-frequency electron exchange and, accordingly, about stability of composition of clusters containing Mn^{2+} and Mn^{4+}. Magnetism of such clusters is displayed below 45 K. Correlation between x, tolerant factor (t) and ΔF be conditioned by polyedrs deformation because of difference of the ion radiuses and structure defects.

Conclusion about inhomogeneity of magnetoresistive manganese-lanthanum perovskites, the real structure of them contains many-valent manganese ions, point and . plane defects was made.

We-PA011

MAGNETOELASTIC ANOMALIES AT FIILD INDUCED PHASE TRANSITIONS IN DOPED MANGANITES

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Magnetostriction $\lambda_{\parallel,\perp}(H)$ and field-induced magnetic and structural phase transitions were studied in the single $Pr_{0.6}Ca_{0.4}MnO_3$, $Pr_{0.65}Ca_{0.28}Sr_{0.07}MnO_3$ and $La_{0.975}A_{0.025}MnO_3$ (A=Ca, Sr) crystals in the pulsed magnetic fields up to 250 kOe at temperatures T=10-300 K. Sharp jumps of transverse $\lambda_\perp$ and longitudinal $\lambda_\parallel$ magnetostriction were observed in $Pr_{0.6}Ca_{0.4}MnO_3$ below charge ordering ($T_{CO} \approx 250$ K) at field-induced phase transitions from an insulating antiferromagnetic (or paramagnetic at $T > T_N \approx 150$ K) state to a metallic ferromagnetic one. Noticeable hysteric phenomena accompanied the magnetostriction behavior. At low temperatures both $\lambda_\parallel$ (H) and $\lambda_\perp(H)$ had a negative sign and a significant volume magnetostriction was observed. Noticeable decrease of the field-induced transverse magnetostriction was observed near and above antiferromagnetic ordering. Temperature dependence of the threshold magnetic field was deduced from the $\lambda_{\parallel,\perp}(H)$ curves. Similar magnetostriction behavior and field induced phase transitions were observed also in the $Pr_{0.65}Ca_{0.28}Sr_{0.07}MnO_3$ with very much more pronounced hysteric and relaxation phenomena. Another kind of the phase transitions were observed in the $La_{0.975}Sr_{0.125}MnO_3$ and $La_{0.975}Ca_{0.125}MnO_3$ associated with a suppression of the Jahn-Teller phase and field induced transitions to a new orbital-ordered ferromagnetic state.
This work was supported in part by Russian Fund for Basic Researches and INTAS (97-30850).

We-PA012

BUFFER LAYER INFLUENCE ON $La_{2/3}Sr_{1/3}MnO_3$ THIN FILMS PROPERTIES.

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SiO_2, YSZ and CeO_2 buffer layers were examined in frame of using in epitaxial growth of doped mangnites on commercial Si and Al_2O_3 substrates. Films structure and film-buffer- substrate interfaces were researched. From SIMS data the film-buffer-substrate interfaces in $La_{0.7}Sr_{0.3}MnO_{3-\gamma}/SiO_2/Si(100)$ was found to be sharp for T_s up to at least 650°C. At higher temperatures film-substrate interface became spread. In the case YSZ and CeO_2 buffer layers there were no any evidence of materials mutual diffusion up to 800° C. Using x-ray analysis YSZ and SiO_2 buffered films were found to be polycrystalline with strong (011) texture, while CeO_2 buffered were epitaxial with (001) axis normal to film plane. Moreover, $LSMO/CeO_2/Al_2O_3$ films had atomically flat surface that was shown with RHEED as well as AFM measurements, that gives a rise to create multilayer structures with fine interfaces. According to their different crystal and stress behaviors poly- and single crystal films had different R(T) and MR(T) dependencies. In CeO_2 buffered films obtained values of magnetoresistance ~ 3-4% at room temperature in 0.11T.
According to mentioned above CeO_2 buffer layer seems to be a good choice for commercial substrates using.

We-PA013

ANTIFERROMAGNETIC RESONANCE IN $La_{1-x}Sr_xMnO_3$ and $La_{1-x}Ca_xMnO_3$ ($0\leq x\leq 0.125$)

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Antiferromagnetic resonance (AFMR) have been studied in $La_{1-x}Sr_xMnO_3$ and $La_{1-x}Ca_xMnO_3$ single crystals for Sr and Ca concentrations $0\leq x\leq 0.125$. A quasi-optical technique was employed in a frequency range $2cm^{-1} < \nu < 30cm^{-1}$ and for temperatures $3K < T < 300K$. Two AFMR modes, a quasi-ferromagnetic (F) and a quasi-antiferromagnetic (AF) mode, were observed in both Sr and Ca doped crystals for temperatures below T_N. A strong decrease of the F-mode resonance frequency was revealed with increasing Sr and Ca concentrations while the resonance frequency of the AF-mode is only slightly decreased (~20%). The effect of the doping on the F-mode frequency is larger for Sr compositions than for Ca ones. The observed concentration dependencies as well as excitation conditions for both modes can be explained using a simple two-sublattice model, which takes into account antiferromagnetic superexchange and double exchange interactions as well as a magnetic anisotropy energy and antisymmetric exchange. These experiments provide direct evidence of a canted antiferromagnetic structure for slightly doped manganites and low temperatures.
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We-PA014

GALVANOMAGNETIC EFFECTS AND THERMOPOWER IN $La_{0.8}Ba_{0.2}MnO_3$ SINGLE CRYSTAL

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We have performed the Hall effect, thermopower, magnetothermopower, magnetic and resistivity measurements on a single crystal $La_{0.8}Ba_{0.2}MnO_3$ with colossal magnetoresistance effect (CMR). Resistivity ρ exhibits a pronounced peak in the vicinity of Curie temperature T_C=250 K, the peak being suppressed and shifted toward higher temperatures by a magnetic field. Thermopower S reveals similar behaviour near T_C. Normal Hall coefficient R_0 is positive near T_C. It reaches a maximum at the same temperature as ρ does and becomes negative for T<200 K. Anomalous Hall coefficient is negative at any temperature revealing a deep minimum near T_C. Hall mobility $\mu_H \approx 0.1\ cm^2/(V\cdot s)$ over 210 K<T<250 K while ρ increases by an order of magnitude. Therefore the activation to mobility edge dominates near T_C, so that CMR is caused by shift of mobility edge. At T<200 K a hopping conduction is predominant.
We have developed semiphenomenological theory which allows the quantitative description of $\rho(T)$ and $S(T)$ curves near T_C.
The work was supported by RFBR.

We-PA015

LOW TEMPERATURE MAGNETORESISTANCE EFFECT IN THE $La_{0.7}Ca_{0.3-x}Sr_xMnO_3$ BULK PEROVSKITE

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The magnetoresistance (MR) of two polycrystalline series of $La_{0.7}Ca_{0.3-x}Sr_xMnO_3$ ($0<x<0.3$) samples formed by nitrate technology and annealed at different temperatures have been investigated as functions of temperature.
X-ray analysis of both series showed that the samples contained a single phase with the distorted perovskite structure. In addition, there was a broad maximum (up to 20° for 2θ) at the low diffraction angles for one series of samples. We interpret the maximum as diffuse scattering on the intergranule medium. In addition to the MR peak, due to the GMR mechanism in the vicinity of the ferromagnetic transition, a significant increase of the magnetoresistance with decreasing temperature is observed in this series of samples. Such behaviour is common for systems with weak bonds between granules. It is found that the low-temperature component of the magnetoresistance depends on the average ionic radii of cations in the A-position. The second series of samples do not have a wide maximum at low angles at the X-ray diagrams and show the magnetoresistance expected for monocrystals. Possible physical mechanisms behind these effects are discussed.

We-PA016

FERROMAGNETIC AND ANTIFERROMAGNETIC DOMAIN OVERLAP IN $Pr_{2/3}Ca_{1/3}MnO_3$

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Zero field muon spin relaxation, neutron diffraction, magnetic and calorimetric measurements have been used in order to investigate the inhomogeneous magnetic nature of $Pr_{2/3}Ca_{1/3}MnO_3$. The use of the implanted muons as a local magnetic probe allows us to discuss the spatial distribution of coexisting ferromagnetic (FM) and antiferromagnetic (AFM) domains. We have found that the ground state is far from a homogeneous canted AFM arrangement of the moments. The muon spin relaxation in $Pr_{2/3}Ca_{1/3}MnO_3$ does not exhibit the thermal dependence characteristic of commensurate $Ln_{1/2}Ca_{1/2}MnO_3$ compounds. The dominant relaxation mechanism of the muon polarization below $T_{CO}\approx220K$ is clearly based on FM Mn-Mn correlations and the relaxation rate is peaked at $T_c\approx120K$ instead of at $T_N\approx155K$. This result, together with the narrow AFM peaks shown by the ND data brings us to conclude that the FM and AFM domains must be strongly overlapped. The low value of the entropy change at T_{CO} measured with differential scanning calorimetry is taken as additional evidence that a huge disorder is kept in the system below T_{CO}.

We-PA017

PHASE COEXISTENCE, CHARGE ORDER AND LOW TEMPERATURE MAGNETIC STRUCTURES OF $Bi_{1/2}Sr_{1/2}MnO_3$

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By means of high-resolution neutron diffraction, magnetization and x-ray thermo-diffraction measurements we have characterized the compound $Bi_{1/2}Sr_{1/2}MnO_3$ over a wide range of temperature. Magnetization, x-ray thermo-diffraction and neutron data confirm that a charge order transition occurs at $T_{CO} \approx$ 500K, below which the coexistence of two phases is observed. Structural analysis of the main phase confirm that the ⟨Mn-O⟩ bond length is considerably larger that in $La_{1/2}Sr_{1/2}MnO_3$. Consequently the ⟨Mn-O-Mn⟩ bond angle is considerably more distorted than in the La manganite, all together revealing that the $6s^2$ lone pair character of the bismuth is not dominant in this compound. Below 150K, the magnetic structures have been determined from neutron diffraction data. In comparison with the CE-type magnetic order of $La_{1/2}Ca_{1/2}MnO_3$, the CO phase of $Bi_{1/2}Sr_{1/2}MnO_3$ presents remarkably different magnetic intensities which have been analyzed in related connection with the anomalously high transition temperature.

We-PA018

COEXISTENCE OF SMALL POLARON AND ITINERENT CARRIERS NEAR T_C IN La-DEFICIENT MANGANITES

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Epitaxial thin films of $La_{0.7}Mn_{1.3}O_{3-\delta}$ have been grown on [001]-oriented $LaSrAlO_4$ substrates by DC-magnetron deposition, as described previously [1]. Magneto-resistivity, thermopower, and magnetic resonance spectra of the films are investigated over a range of temperatures and magnetic fields.
An effective medium approach is used, phenomenologically, to provide a quantitative explanation of La-deficient film samples properties both above and below Curie temperature T_C. We explore the possibility that observed transport and magnetic resonance peculiarities arise from an intrinsic electric and magnetic inhomogeneity of the samples near T_C. That is, the semiconductive regions with magnetic polaronic conductivity as in the paramagnetic phase of $La_{0.7}Mn_{1.3}O_{3-\delta}$ do persist with the ferromagnetic phase with metallic conductivity. As far as the metallic resistivity switches on quickly as the system orders, the metallic regions appear as stripelike domains with low percolation threshold. We discuss the mean-field model in which a field- and temperature- dependent concentration of metallic regions within a semiconductive, is a secondary order parameter. The model reproduces the qualitative features of the experimental data.

[1] Krivoruchko V.N., Khartsev S.I., Prokhorov A.D., Kamenev V.I., Szymczak R., Baran M., Berkowski M. // JMMM (1999) to be published.

We-PA019

GIANT RED SHIFT OF ABSORPTION EDGE DUE TO FERROMAGNETIC ORDER IN $La_{0.9}Sr_{0.1}MnO_3$

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The spectra of the diffuse reflectivity in the near-infrared and visible range ($0.5 \leq E \leq 2.8$eV) were measured for a powder sample $La_{0.9}Sr_{0.1}MnO_3$ at the temperature region $135 \leq T \leq 180$K that was included the Curie point T_c=155 K. The absorption spectra were obtained by a modified Kramers-Kronig analysis of the reflectivity data. Absorption coefficient α was increased with E at nearly linear law. Therefore the absorption edge energy was determined as the point of intersection the $\alpha(E)$ curve with E-axis. It has been found that the absorption edge energy shifts from 1.0 to 0.6eV with temperature drop from T_c to 135K. A small blue shift, characteristic for nonmagnetic semiconductors, occurs above T_c. Thus giant red shift of fundamental absorption edge due to ferromagnetic (F) order was determined in this sample. This giant red shift of the band gap seems to be due to a shift of the valence-band top, since holes in the indicated compound propagate via manganese ions, with which they have a strong *p-d* exchange interaction. This means that the energy of the charge carriers (holes) decreases with increasing degree of F order in $La_{0.9}Sr_{0.1}MnO_3$. This compound is an antiferromagnetic semiconductor $LaMnO_3$, of which a doping of Sr produces a spontaneous magnetization. It seems plausible that this spontaneous magnetization is conditioned by F microregions, formed by holes around impurities. Here their localization, besides a gain in *p-d* exchange, gave rise to Coulomb attraction of holes to acceptors. The theory of magnetic impurity states was worked up by Nagaev, Yanase and Kasuya.

We-PA020

SPECTRAL AND TIME-RESOLVED PHOTORESPONSE IN $Nd_{2/3}Sr_{1/3}MnO_{3-d}$ EPITAXIAL LAYERS

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The resistivity of oxygen deficient $Nd_{0.67}Sr_{0.33}MnO_{3-d}$ epitaxial layers shows a double peak which has been interpreted in terms of a sequence of (temperature-induced) phase transitions. The time-resolved photoresponse is observed in a TTE-geometry using different light intensities in spectral windows in the visible. In the regime of the low temperature resistivity peak the photoresponse increases sharply and shows saturation with increasing light intensity, suggesting a light induced transition. The TTE (time resolved thermoelectric effects)- method allows to simultaneously measure the heating of the sample under illumination and also allows to detect nucleation and growth of a light-induced phase.

[1] A. Kattwinkel, J. Liebe, L. Haupt, G.H. Rao, K. Bärner, E. Gommert, J. Wecker, R.V. Helmolt, R. Braunstein, Physica B (1999) in print

We-PA021

MAGNETIC AND MAGNETOCALORIC PROPERTIES OF $La_{1.4-X}Yb_XCa_{0.6}Mn_2O_7$

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Magnetic and magnetocaloric properties of $La_{1.4-X}Yb_XCa_{1.6}Mn_2O_7$ system were studied. Polycrystalline samples with x = 0 and 0.2 were prepared by solid state reaction. The XRD patterns evidenced the presence of only one phase having orthorhombic symmetry. The SEM study revealed that samples are composed from grains having average dimensions (3-5) μm. Magnetic measurements show that Curie temperatures decrease from 246K for x = 0 up to 211K for x = 0.2. The magnetic entropy change, ΔS was obtained from magnetization data. The temperature dependences of the ΔS show peaks close to the magnetic transition temperatures. Peak values of ΔS_m = 2.7 J/kg K and 2.1 J/kg K were obtained for compositions x = 0 and 0.2. The decrease in ΔS_m when changing composition can be correlated with the diminution of exchange interactions. The large magnetocaloric effect suggests that those materials are suitable candidates for magnetic refrigerants.

We-PA022

VOLUME AND ANISOTROPIC SPONTANEOUS STRICTION IN LAYERED MANGANITES: ROLE OF CHARGE LOCALIZATION AND MAGNETIC INTERACTIONS

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Thermal expansion measurements have been performed on single crystals of the layered manganites $R_{2-2x}Sr_{1+2x}Mn_2O_7$ over a wide temperature range (4-900 K). We have selected for our analysis four compounds (with R= La, Pr, Nd and Dy) which are representative of the series, from the point of view of their different low temperature magnetic and transport properties. Our analysis allows us to give a general explanation for the large lattice anomalies observed in this layered manganite series. Localization of the carriers gives rise to proportional volume (ω) and anisotropic (λ_{PM}) anomalies starting in the paramagnetic regime. An additional contribution to the anisotropic distortion (λ_{AF}) appears with the establishment of long-range antiferromagnetism, whereas ω and λ_{PM} are quenched by long-range ferromagnetic order.

We-PA023

THE EFFECT OF ANNEALING ON MAGNETO-OPTICAL PROPERTIES OF $(La\text{-}Pr)_{0.7}Ca_{0.3}MnO_3$ CERAMICS

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Different kinds of phase separation and inhomogeneous states including FM and CO droplets, magnetic polarons and stripes are considered for explanation physics properties of doped manganites. The annealing may produce the thermodynamical equilibrium change and increasing or homogenization of some phases. Especially this effect is most pronounced in compositions where the transition points corresponding to different types of ordering are close to each other. For compound $(La_{1-x}Pr_x)_{0.7}Ca_{0.3}MnO_3$ is it at x=0.75, where ground FM state change of AFM. In this report we present the result of the study of the effect of annealing on the magneto-optical (MO) properties of $(La_{1-x}Pr_x)_{0.7}Ca_{0.3}MnO_3$ (x=0; 0.75) ceramic samples. The transversal Kerr effect (TKE) spectra were measured after annealing at T=800°, 900°, 1000°, 1200° and 1400° C (sintered temperature T_{sin}=1200^0). It was found, that the shape and magnitude of M-O spectra depend on annealing temperatures. The temperature hysteresis of the spectral dependencies for samples annealed at T< T_{sin} suggests a charge carrier redistribution between ferromagnetic cluster and charge ordered AFM matrix when $T_C<T_N$. The samples annealing at T> T_{sin} causes the switching of the hysteresis with increasing T_C up to 150K. The additional annealing at T< T_{sin} gives rise the original thermal hysteresis and FM phase with T_C=110K.
This complex TKE behaviour evidences the possible coexistence of the phases with different magnetic order and the charge carrier redistribution on the commencement of the magnetic phase separation.

We-PA024

CORRELATION BETWEEN ELECTRONIC AND MAGNETIC STRUCTURES OF MANGANITES

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Within the framework of a tight binding method analytical expressions of dispersion curves E(κ) for e_g-electron in perovskites $RMnO_3$ (R=La, Pr, Nd, Sm etc.) for the basic types of magnetic ordering in Mn – sublattice (A, C, G etc.) are found. As well as in the majority of modern papers, it was supposed, that the spin of the carrier is always oriented along a local spin of manganese ion formed by t_{2g} -electrons. For the first time the dispersion curves E (κ) taking into account an oxygen and rare earths (RE) subsystems are obtained.
In order to get the conditions of phase separation in RE – manganites for different types of mutual magnetic ordering in Mn and rare earths (RE) sublattices the calculated dispersion curves E (κ) have been used. The role of manganese e_g -level degeneration in phase separation has been surveyed. These data are necessary for an explanation of the phase diagrams, observed on experiment.

We-PA025

MESOSCOPIC INHOMOGENEITY OF THE REAL STRUCTURE AND MAGNETORESISTANCE IN $La_{0.6}Sr_{0.2}Mn_{1.2-x}Cr_xO_3$ MANGANESE-LANTHANUM PEROVSKITES

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$La_{0.6}Sr_{0.2}Mn_{1.2-x}Cr_xO_3$ single-phase ceramic magnetoresistive samples were investigated by X-rays structural, magnetic, resistance and NMR methods. Real perovskite-like structure ($R\bar{3}c$) was established to contain subtraction defects simultaneously in cationic and anionic sublattices. More complicated mesoscopic defects of plane type, so-called clusters, were discovered by X-rays structural method. Structural type and size of clusters containing superposition of many-valent ions (first of all Mn^{2+} and Mn^{4+}) and vacancies were determined. With x increasing ^{55}Mn NMR spectrum from $(Mn^{3+})_B$ and $(Mn^{4+})_B$ ions taking part in high-frequency exchange (f≈342 MHz) is widening asymmetrically to the side of low frequencies. At x>0.05 spectrum is partially distributed on some components because of violation of high-frequency electron exchange by Cr ions and defects and transition of part of Mn^{3+} and Mn^{4+} ions to more localized states. Another part of Mn^{4+} jointly with Mn^{2+}, placed in distorted polyedrs, and vacancies form non-magnetic clusters. Magnetism of these clusters is displayed below 45 K. The x increase from 0 to 0.2 leads to magnetization decrease and lowering temperatures of "metal-semiconductor" (from 367 to 302 K), "ferro-paramagnetic" (from 370 to 306 K) transitions and magnetoresistance peak (from 348 to 293 K). Magnetoresistance, measured at 5 kOe, was grew to 1.5 times.

We-PA026

TRANSPORT AND MAGNETORESISTANCE PROPERTIES OF NANOCRYSTALLYNE $La_{0.70}Ca_{0.30}MnO_3$

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High quality polycrystalline samples of $La_{0.70}Ca_{0.30}MnO_3$ were prepared using method of precipitation from solutions [1]. Results of both x-ray diffraction and scanning electron microscopy investigations allow to estimate average crystallite size d ≅ 19 nm. Electric resistivity (ρ) and AC magnetic susceptibility (χ) measurements were performed in the temperature (T) range 77 K - 370 K, magnetoresistance (MR) was studied in fields up to 1.5 T.
Magnetic measurements show relatively sharp paramagnetic to ferromagnetic transition at T_C = 265 K. Both $\rho(T)$ and MR(T) curves exhibit peaks near T_C, in agreement with literature data [2]. Additionally, broad resistivity peak is observed at T ≅ 230 K which is not accompanied with any anomaly on $\chi(T)$ and MR(T) curves. The results are discussed in terms of persistence of paramagnetic semiconducting phase down to the lowest temperatures, the increased amount of the phase being caused by developed crystallite surface area.

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[2] Jeffrey Snyder G. et.al.// Phys. Rev. B53 (1996), p.14434.

We-PA027

TRANSPORT PROPERTIES OF DOPED MANGANITES IN CASE OF DEGRADED MAGNETIC TRANSITION

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Strong interplay between electronic behavior, structure and magnetism in doped manganites gives rise to the enhanced sensitivity of transport properties to magnetic and structural peculiarities. Specifically, the resistivity maximum serving as a prerequisite of colossal magnetoresistance is originated from the transition from paramagnetic semiconducting to ferromagnetic metallic state. However, as shown in Refs. [1-2], in some peculiar cases polycrystalline samples as well as epitaxial films of manganites can exhibit additional low-temperature resistivity peaks which are not associated with any magnetic or structural transition, and nature of which remains unclear hitherto. We propose that such anomalies in the materials under consideration may simply be a result of the degradation of ferromagnetic transition. In the framework of the percolation model we have analyzed the behavior of a system consisting of paramagnetic and ferromagnetic phases which have different types of conductivity and coexist over a wide temperature interval. It is shown that in spite of the monotonic variation of the magnetic and electric properties of each phase, the resulting resistance may exhibit various anomalies in the region of coexistence of phases. The calculated data are shown to be in good agreement with experimental ones observed in strained epitaxial $La_{0.6}Sr_{0.4}MnO_3$ films [2].

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[2] Izumi M. et al.// Appl. Phys. Lett. 73 (1998), p.2497.

We-PA028

ANOMALIES OF MAGNETOELASTIC AND MAGNETOTRANSPORT PROPERTIES AT CURIE POINT FOR $Re_{1-x}Sr_xMnO_3$ (Re = Sm, Nd) COMPOUNDS

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Magnetization, *ac* initial magnetic susceptibility, resistance, magnetoresistance, thermal expansion and magnetostriction measurements were performed for $Re_{1-x}Sr_xMnO_3$ (Re = Sm, Nd, x = 0.45; 0.33) compounds. It is found the close connection between magnetic, transport and elastic properties for $Sm_{0.55}Sr_{0.45}MnO_3$ sample. At Curie point T_C = 126 K we have observed the large volume contraction $\Delta V/V \approx 0.1\%$, an abrupt minimum on the temperature dependence of negative volume magnetostriction $\omega(T)$ and a maximum on the temperature dependence of resistivity. The anisotropic magnetostriction changes sign at T_C, it is positive below T_C and negative above T_C. The volume magnetostriction isotherms are not saturated in the magnetic field up to 1 T and the clear hysteresis are observed during increase and decrease of magnetic field in the T_C region. Besides, we observed the temperature hysteresis of the thermal expansion and magnetostriction below T_C. These facts point out on the first order phase transition at T_C. We have obtained giant negative volume magnetostriction $\sim 5 \cdot 10^{-4}$ in a relatively low magnetic field H = 0.9 T which is accompanied with colossal negative magnetoresistance equal to 44% in the same magnetic field. For $Nd_{1-x}Sr_xMnO_3$ (x = 0.45; 0.33) compounds volume magnetostriction is one order of magnitude less than for $Sm_{0.55}Sr_{0.45}MnO_3$ sample. It is positive below 160 K and negative above 160 K. The $\omega(T)$ curves go through minimum at T_C = 265 K for x = 0.45 compound and T_C = 242 K for x = 0.33 compound. Magnetoresistance of these compounds are equal to ~12% in H = 0.9 T. Described above properties are explained by the existence magnetic two-phase state, just like that as in usual magnetic semiconductors of EuSe and $CdCr_2Se_4$ type.

We-PA029

THE INFLUENCE OF HIGH PRESSURE TREATMENT ON THE MAGNETIC AND TRANSPORT PROPERTIES OF THIN LANTHANUM MANGANITE FILMS

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Very high values of magnetoresistance are observed for thin films of half-metallic manganites. It was shown [1], that extremely large (till ~127000%) variations of magnetoresistance can be observed under medium (3 atm.) pressure annealing of the films in oxygen. Since that time the results of numerous studies were published dealing with various aspects of thin manganite films preparation and investigations of their physical properties. But the influence of the oxygen pressure treatment on the structural and physical properties had received very little attention. The influence of ordinary (in flowing oxygen) and high (100 bar) pressure annealing on the magnetotransport, magnetic, and structural properties of pulsed laser deposited $La_{0.67}Ca_{0.33}MnO_3$/(100)MgO thin films was studied in the present work. Low pressure annealing results in relatively weak improvement of the magnetic and transport properties of the films. The high pressure treatment weakens double exchange, enhances magnetoresistance and leads to hysteresis phenomena. The results are interpreted in terms of magnetic interactions modifications and their influence on the transport properties due to the possible preferential incorporation of the interstitial oxygen.

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We-PA030

VARIATION OF THE MAGNETIC PROPERTIES OF RARE EARTH-DOPED La-(Sr,Ba,Pb) BULK POLYCRYSTALLINE SINTERED MANGANITES

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Strong coupling between the magnetic, transport, and structural properties of doped manganites had renewed the interest to this class of complex oxide compounds. Some relations between the Curie temperature and various parameters, like average ionic radius on the A site or variance of the A-cation radius distribution, were proposed for these half-metallic ferromagnetic materials. We analyze the evolution of the magnetic properties of $La_{0.60}R_{0.07}Di_{0.33}MnO_3$ (Di=Sr,Ba,Pb) bulk sintered manganites with the magnetic rare earths R doping. It is shown that introduction of the magnetic rare earth ions leads to the ferromagnetic coupling between the Mn and R spins. The Curie temperature for doped compositions is lower than that for the undoped ones. The depression of the Curie temperature correlates with the effective moment of the rare earth ion. The results for compositions with different divalent cations are compared. The observed relations are interpreted in terms of the weakening of the double exchange in the presence of the supplementary weak ferromagnetic interaction due to the presence of the additional A-site disordered magnetic moments. These results are clearly indicating that the cation size and cell distortions are not the only factors leading to the reduction of the Curie temperature in doped ferromagnetic manganites.

We-PA031
POLYCRYSTALLINE PERORVSKITE MANGANESE OXIDE FILMS OBTAINED BY LASER ABLATION

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With regards to application to sensors, the $La_{0.7}Sr_{0.3}MnO_3$ polycrystalline films are well-suited systems, owing to its relatively high Curie temperature (about 360 K) and the saturating behaviour of the magnetoresistance due to the grain-boundary transport contribution [1]. Therefore, we have grown $La_{0.7}Sr_{0.3}MnO_3$ polycrystaline thin films by pulsed laser deposition (PLD). The PLD was performed with a KrF laser (248 nm., 200-300 mJ). The targets were produced by ceramic and sol-gel method. The substrates used were polycrystalline Al_2O_3 and Si with an amorphous SiO_2 buffer layer. The films were heated during the deposition at about 550° C and were crystallines without need of further annealing. Microstructure study was performed by X-ray diffraction and scanning electron microscopy. Magnetic and transport measurements have been performed, and similar values of T_C and GMR to that of the bulk have been found (the latter reaches 4 % at 1 T and at room temperature). Thus, it seems fairly interesting for obtaining magnetic sensors based in manganite oxides.

[1] R. Shreekala, et.al. // Appl. Phys. Lett., 71, (1997), p.282.

We-PA032
MAGNETIC MICROSTRUCTURE OF CMR $La_{0.7}Sr_{0.3}MnO_3$ THIN FILMS GROWN ON (001)$LaAlO_3$ SUBSTRATES STUDIED BY MAGNETIC FORCE MICROSCOPY

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Colossal Magnetoresistive (CMR) $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) thin films (≈ 1500Å) have been deposited by the Pulsed Laser Deposition technique on pseudo-cubic $LaAlO_3$ (001)-oriented substrates (a ≈ 3.79Å). X-ray diffraction measurements evidence that the films are single phase. Depending on the growth conditions (mostly the synthesis temperature) , the out-of-plane parameter varied from of 3.92 Å or 4.00 Å. Atomic Force Miscroscopy study reveals similar granular surfaces for all films, with grains with an average diameter of 600 Å. Black and white contrasts characteristics of films with an out-of-plane magnetization are imaged using Magnetic Force Microscopy. However, depending on the out-of-plane parameter, two out-of-plane magnetic patterns are showed. On samples with the out-of-plane parameter of 3.92 Å, a "maze-like" pattern is imaged while on samples with a larger out-of-plane value of 4.00 Å, large domains with a diameter of about 5 μm are evidenced. We conclude that the magnetic microstructure of LSMO films deposited on $LaAlO_3$ substrates is strongly influenced by the growth conditions. The magnetic domains shape will be correlate to the out-of-plane parameter of the film.

We-PA033
PROPERTIES OF LaCdMnO CERAMICS AND THIN FILMS

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Sahana et al [1] investigated the $La_{0.67}Cd_{0.33}MnO_3$ compound. They found a rhombohedral structure with a metal-insulator transition of 255 K in bulk ceramic samples and 250 K in laser ablated thin films. These results are comparable with the $La_{0.67}Ca_{0.33}MnO_3$ system, as supposedly expected thought similar ionic radii of Ca^{2+} and Cd^{2+}. In their work the possibility of Cd volatilization is not stressed and only nominal compositions are quoted. We tried to reproduce such results, comparing the addition of Cd and Ca to the same basic $La_{0.65}\square_{0.35}MnO_3$ manganite, paying special attention to possible Cd losses. Magnetic and electric measurements show, contrarily to what was observed by Sahana et al, that Cd reduces Tc much more strongly than Ca when incorporated. This would not be expected if Cd occupies the same site as Ca since they have a very similar ionic radius (1.15 and 1.16 Å). This suggests that Cd may occupy a Mn site, like Zn, Fe, Cr and Co, being Sahana et al results explained by a partial or complete volatilization of Cd.

We-PA034
EVOLUTION MAGNETORESISTANCE IN EPITAXIAL THIN FILMS $(La_{0.5}Pr_{0.5})_{0.7}Ca_{0.3}MnO_3$ DUE TO OXYGEN ISOTOPE SUBSTITUTION

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A colossal shift of the maximum resistivity temperature and giant magnetoresistivity induced by oxygen isotope exchange was registered for 60 nm thick films of the manganite $(La_{0.5}Pr_{0.5})_{0.7}Ca_{0.3}MnO_3$ on perovskite substrates: $LaAlO_3$ and $SrTiO_3$. The magnitude of the effect depends on lattice strain resulting in the largest shift for the film on $LaAlO_3$: the ^{16}O sample showed a metal – insulator transition at 182 K, whereas the ^{18}O sample was insulating down to 4.2 K, which is the highest difference ever reported for CMR manganites. While a large (about 60 K) shift of T_C was observed for the film on the $SrTiO_3$ substrate after isotope substitution. Unusual discrepancy in electric and magnetic properties between films on $LaAlO_3$ and $SrTiO_3$ substitution was explained by different additional strains induced by substrates. Evolution magnetoresistance for these films was found. The results are consistent with the model coupling the metal-insulator transition in the perovskite manganites to the lattice dynamics.

We-PA035

MÖSSBAUER STUDIES OF PEROVSKITE $La_{0.67}Ca_{0.33}Mn_{1-x}Fe_xO_3$

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The perovskite of $La_{0.67}Ca_{0.33}Mn_{1-x}{}^{57}Fe_xO_3$(x= 0, 0.01, 0.03, and 0.05) compounds have been studied with Mössbauer spectroscopy, vibrating sample magnetometer(VSM), and X-ray diffractometer. The $La_{0.67}Ca_{0.33}Mn_{1-x}{}^{57}Fe_xO_3$ powders have been prepared by sol-gel processing method. Mössbauer spectra of $La_{0.67}Ca_{0.33}Mn_{1-x}{}^{57}Fe_xO_3$ powders have been taken at various temperatures ranging from 4.2 K to room temperature. The line width of each Lorentzian 6-line at 4.2 K was broaden in proportion as doped ^{57}Fe increased. Analysis of ^{57}Fe Mössbauer spectrum data has considered nearest-neighbor interactions and anisotropic hyperfine field fluctuation[1]. Analysis of ^{57}Fe Mössbauer data in terms of the local configurations of Mn atoms has permitted the influence of the magnetic hyperfine interaction to be monitored. The values of the isomer shifts show that all the iron ions are in the ferric(Fe^{3+}) state. The temperature dependence of the resistance under zero and 10 kOe applied magnetic field shown that a semiconductor-metal transition temperature, $T_{SC\text{-}M}$, decreased from 274 to 155 K in proportion as doped ^{57}Fe increased. The relative magnetoresistance(MR) of the $La_{0.67}Ca_{0.33}Mn_{0.97}{}^{57}Fe_{0.03}O_3$ is about 45 % at the $T_{SC\text{-}M}$=210 K.

[1] M. Blume and J. A. Tjon // Phys. Rev., 165, (1968), p.446 ; D. G. Rancourt, S. R. Julian and J. M. Daniels // J. Magn. Magn. Mat., 51, (1985), p.83.

WE-PA036

MAGNETIC PROPERTIES AND MAGNETORESISTANCE IN $Fe_{1-x}Cr_2S_4$(x=0.0, 0.04, 0.08)

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Samples of $Fe_{1-x}Cr_2S_4$(x=0.0, 0.04, 0.08) with varying Fe content around the nominal composition have been studied with Mössbauer spectroscopy, X-ray photoelectron spectroscopy(XPS), Rutherford back scattering(RBS), vibrating sample magnetometer(VSM) and magnetoresistance(MR). The purpose of these reports is to study the effects of a small Fe-deficiency and conduction mechanism on $FeCr_2S_4$. The samples were synthesized by the usual ceramic method and the crystal structure was examined by powder x-ray diffraction. In order to study charge carrier and magnetic property, the Mössbauer spectra were recorded from 4.2 K to room temperature. From the temperature range 13 K to 100 K the asymmetric line broadening is observed and considered to be dynamic Jahn-Teller distortion. Isomer shift value of the sample x=0.04 at 170 K was 0.6 mm/s, which means that charge state of Fe ions is ferrous in character. The Curie temperatures of the samples(x=0.0, 0.04, 0.08), were determined to be 172, 170, 169 K, respectively. However, as increasing Fe deficiency, the peak of maximum MR ratio of x=0.0, 0.04, and 0.08, were occurred at 171, 174, and 186 K, respectively. The separations of the temperatures between the maximum MR temperature and the magnetic ordering temperature are increased gradually. From the above results we conclude that the conduction mechanism in these systems is different from the double exchange mechanism in a point that there were no mixed charge valences.

We-PA037

MAGNETIC PROPERTIES OF FRUSTRATED CMR $FeCr_2S_4$ FERRIMAGNET

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Ferrimagnetic $FeCr_2S_4$ semiconductor exhibits half- metallic properties and colossal magnetorezistance (CMR) and is of interest for CMR applications [1]. We present the results of the magnetic properties investigations of $FeCr_2S_4$ single crystals by means of ESR technique and Foner vibrating sample magnetometer at normal and high pressures.
The reentrant behavior of magnetization at temperatures T< 58 K as well as the substantial difference between zero field cooled (ZFC) and field cooled (FC) magnetization and appearance of the thermoremanent magnetization were found. High non- linearity of the magnetization curves, strong relaxation and shifted hysteresis loops at T< 15 K were observed. In the FMR spectra the second resonance line has been found at T<90 K besides the first one observed at $T< T_C$. These lines have the non- monotonous temperature dependences and the second line disappears at T< 58 K. With the increase of pressure the considerable shift to the higher temperatures of the splitting point of ZFC and FC magnetization was observed. The colossal pressure effect on the ferri- to paramagnetic phase transition ~1.2 K/kbar was also found. The origin of the frustrated states observed for the first time in this material and of the colossal magnetorezistance studied on the same single crystals are discussed with the particular attention to the Jahn- Teller effect.

[1] Ramirez A. P., Cava R. J., Krajewski J. // Nature, 386, (1997), p. 156.

We-PA038

FERROMAGNETIC AND SPIN - WAVE RESONANCES IN THE $La_{0.7}Mn_{1.3}O_3$ FILM

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In this work, the angle and temperature dependencies of ferromagnetic resonance (FMR) lines in the epitaxial $(La_{0.7}Ca_{0.3})_{1-y}Mn_{1+y}O_3$ films are presented. Measurements were performed using an X-band spectrometer (at 9.235 GHz). The 3000 Å films were prepared by both the pulsed-laser deposition and magnetron sputtering on $LaAlO_3$ substrates. The best films show reasonably narrow FMR linewidth (about 0.1-0.2 kOe) in both parallel and perpendicular geometries, confirming their high magnetic homogeneity. By comparing resonance fields oriented parallel and perpendicular to the film plane, the easy axis of magnetization (M) was shown to be perpendicular to the plane. Based on a study of temperature and angular dependencies of the FMR and spin wave resonance (SWR) spectra, M(T) dependence, constants of an exchange interaction and magnetic anisotropy were established. The classical form of SWR spectrum was observed. It consist of the clearly visible several modes in the monocrystal $La_{0.7}Mn_{1.3}O_3$ film below temperature of 165 K. Magnetic field and temperature dependencies of SWR behavior confirm that the dynamic mechanism of spins pinning at the film surface is dominant. The excitation of SWR is shown to be due to the surface anisotropy resulting from annealing of film in oxygen. The standing spin-wave resonances is found to depart from the n^2-law at n<5. This effect seems to be due to the fluctuations of the exchange interaction resulting from a presence of film inhomogeneities.

We-PA039
IMPEDANCE OF A MAGNETIC SANDWICH

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A two-dimensional model for the impedance of a three-layer structure consisting of a non-magnetic conductor sandwiched between two conductive magnetic layers in presented. The theory is based on solving Maxwell's equations for the electromagnetic fields and Landau-Lifshitz equations for the magnetization vector with appropriate boundary conditions at the interfaces between the layers and at film's surfaces, and describes the properties of the system in a wide frequency interval, including the ferromagnetic resonance range.
Two sandwich strip structures, with the thickness much less than the width, are studied: a "closed" structure with magnetic closure at the edges along the width and an "open" structure without flux closure, in which all layers have the same width. The impedance for the two structures is calculated and its dependence on the physical parameters and frequency is analyzed. For the "open" structure, the inductance is shown to decrease monotonically with frequency and its dc value increases with increasing width, which indicates that edge effects play a dominant role. In the "closed" structure, the edge effects are not pronounced. As a result, this structure is more efficient magnetically and exhibits a highly inductive response to much higher frequencies than the "open" structure. The obtained results are directly applicable to practical design of GHz inductive components.

We-PA040
MODEL DESCRIPTION OF GIANT MAGNETOIMPEDANCE FOR THIN FILMS

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As it was pointed out in the work [1]: "Calculation of giant magnetoimpedance (GMI) and ferromagnetic resonance response are rigorously equivalent". The authors discussed the problems of a description of the "... GMI in soft magnetic fibers, wires, and ribbons".
In the work [2] we presented the model of the propagation of the electromagnetic waves along thin magnetic films (TMF). This model describes the case when the wavelength of an external electromagnetic field (EEF) $\lambda >> h$, the film thickness, but less the linear size of the TMF plane. The response on the EEF was found as $\chi = \frac{\chi_0}{1-2\pi i\kappa h\chi_0}$, where κ is the wave vector and χ_0 is the susceptibility of the material of TMP. It is easy to show that in the case when frequency of EEF is near to the FMR frequency the absorbed by TMP energy $\Rightarrow \frac{H^2}{8\pi}$.

[1] Yelon A., D.M\'enard, M.Britel, and P.Ciureanu. //Appl.Phys.Lett. 69, (1996), p.20.
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We-PA-041

ELECTROMAGNETIC FIELD PENETRATION THROUGH Fe/Cr SUPERLATTICE IN WIDE FREQUENCY RANGE

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Electromagnetic field penetration is one of the most suitable methods for the investigation of the high-frequency GMR effect. The penetration of microwaves through the Fe/Cr superlattice has been studied in [1] and one-to-one correspondence is established between the penetration and dc magnetoresistance. The penetration of the electromagnetic waves in a wide frequency range is investigated here in the Fe/Cr superlattices. There are two different frequency intervals of interest. In the first one, at lowest frequencies on the order of tens of kilohertz, where $1/(\sigma\delta Z) >> \delta/L$ the transmission coefficient is practically independent of magnetic field intensity. Here σ is an effective conductivity, δ the skin depth, L the total thickness of metal, Z the impedance of the outer space. In the second interval, at the higher frequencies where the inequality is valid $L<0.5\delta$, the transmission coefficient D is inversely proportional to the effective conductivity: $D=2/(Z\sigma L)$. In this frequency interval the relative deviation of the transmission coefficient in magnetic field tends to the relative magnetoresistance. All these features are confirmed experimentally. The work is supported by grants of RFBR №98-02-17553 and №98-02-17517.

1. Ustinov V.V., Rinkevich A.B., Romashev L.N., Minin V.I. // JMMM, 177-181 (1998), p.1205

We-PA042

ALTERNATING MAGNETIZATION OF COLD-DRAWN PERMALLOY-COPPER COMPOSITE WIRES BY RADIO FREQUENCY CURRENT

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The alternating magnetization in composite wires carrying radio frequency current is studied. The cold-drawn wires consisting of Cu inner core (diameter from 20 to 120 μm) and NiFe outer shell (thickness from 10 to 40 μm) are used. The measurements are made using wave-guide technique. The AC current having the frequency up to $f = 4$ MHz and the amplitude $I_0 = 0\text{-}50$ mA is passed through the samples. The wires are placed in the longitudinal DC magnetic field H_{dc}. The pick-up coils are wounded around the samples. The first harmonic dominates in the frequency spectrum of the pick-up coil voltage at low I_0. If I_0 exceeds some threshold value, the odd harmonics disappears, while the amplitudes of even harmonics continue to increase with I_0. The dependencies of the amplitudes of several even harmonics on I_0 and H_{dc} are measured. A high field sensitivity of the even harmonic amplitudes of the order of 1 V/Oe is demonstrated. The experimental results are interpreted in terms of Faraday law and Stoner—Wohlfarth magnetization reversal. The peculiarities of the frequency spectrum of the pick-up voltage are discussed and compared with the experimental data. We assume that the effect studied gives the possibility for a design of magnetic field sensors.

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We-PA043

MACROSCOPIC MODEL OF MAGNETO-IMPEDANCE MEDIA BASED GRANULAR SYSTEM.

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Recently, it has been shown that intergrain electrical contacts between adjacent granules are responsible for a number of linear and nonlinear electromagnetic phenomena in granular alloys (see for example [1,2] and references therein). The mixture of metallic and nonmetallic balls of macroscopic size is very convenient model system to study the role of contacts in granular alloys [1]. We present the results of experimental study of magneto-impedance and magnetic properties in mixtures of nickel-coated polystyrene balls. Balls with diameter of 5 or 0.7 mm were covered by nickel with thickness of 10μm.
Magnetic properties were measured for a single ball and for clusters composed of 2-5 balls with various configurations (chain, triangle, square). Magnetic moments of clusters are not additive. This features could be very likely connected with intergrain contacts.
The magneto-impedance measurements were performed at frequencies ranging from 50 Hz up to 1 MHz at different ac current amplitude provided linear and nonlinear modes of operation. The oscillations of real and imaginary components of impedance were discovered at low frequencies

[1] J.P. Clerc, F.Brouers and A.Sarychev, Physica A241 (1997) 289
[2] V.Shalaev and A.Sarychev, Phys.Rev. B 57 (1998) 13265

We-PA044

ANISOTROPY OF MAGNETORESISTANCE IN $TmBa_2Cu_3O_x$ SINGLE CRYSTAL CAUSED BY RECONSTRUCTION OF AFM DOMAIN STRUCTURE

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The experiments with the easy-plane tetragonal antiferromagnet (AFM) $TmBa_2Cu_3O_x$ [1] show the field and temperature dependent anisotropy of magnetoresistance measured in-parallel and perpendicular to the magnetic field direction. In the present paper this effect is explained by reconstruction of the AFM domain structure on the basis of the phenomenologic theory of thermodynamically equilibrium domain structure.
Anisotropy of magnetoresistance is supposed to be proportional to the magnetostriction averaged over the sample and so, depends upon the domain distribution. The AFM domains with perpendicular orientation of AFM vectors are treated as magnetoelastic ones. Their formation and reconstruction is governed by the strain compatibility conditions that suppress the nonzero average strains. The external magnetic field produces the shift of the AFM domain walls and reorientation of the AFM vector. The first process gives rise to redistribution of the domain structure in such a way that the effective internal field is directed symmetrically with respect to AFM vectors in different domains. The critical field of monodomenization is proportional to the magnetoelastic constant. Its temperature dependence is deduced from the thermodynamic probability of the domain wall depinning. The observed irreversibility of the magnetoresistance after the field cycling is explained by the reorientation of AFM vectors in the regions with pinned domain walls. Calculated irreversibility decreases with temperature growth, in accordance with the experimental data.

[1] Amitin E.B., Baikalov A.G., Blinov A.G., et al., // Pis'ma ZhETF, **70**, №5, (1999), p.350.

We-PA045

NONLINEAR (QUADRATIC IN CURRENT) HALL EFFECT OF ANTIFERRO-ELECTRIC ORIGIN

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New galvanomagnetic effect is predicted in conductive antiferromagnetics (AFs) having a centerantisymmetric magnetic structure. This is nonlinear (quadratic in electric current $\vec{J}$) Hall effect – transverse to $\vec{J}$ electric field $\vec{E}_\perp$ (potential difference), even at magnetic field $\vec{B} \to 0$. The effect is connected with the terms of the type $L_i E_i$ in resistivity tensor $\hat{\rho}$ ($\vec{L}$ - antiferromagnetic vector). That violates Ohm's Law giving antisymmetric components $\rho_{ij} = -\rho_{ji} \propto LE$. Various geometrical situations are considerid for tetragonal (such as trirutiles Fe_2TeO_6, etc) and tetragonal (such as oxides Cr_2O_3, etc). Two examples only.

Tetragonal AFs with the magnetic structure $\overline{1}(-)4_Z(-)2_d(-)$, $\vec{L} \parallel 4 \parallel Z$ at $\vec{J} \perp Z$ and $\vec{B} = 0$: $E_\perp^Z = -\lambda_1 L_Z (J_X^2 - J_Y^2)$ (λ_i - constants).

Trigonal AFs with the structure $\overline{1}(-)3\ (+)2\ (-)$ (at $B_Z > H_{sf}$ if it is an easy axis case), $\vec{J} \parallel Y$, $\vec{L} \parallel X$: $E_\perp^Z = -\lambda_2 L_X J_Y^2$, $E_\perp^X = \dfrac{RB_Z J_Y}{1 - \lambda_3 L_X J_Y}$

(R - the constant of the usual Hall effect).

We-PA046

HALL EFFECT MEASUREMENTS ON ANISOTROPIC FERROMAGNETIC THIN FILMS

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We made Hall effect measurements on thin films consisting of Permalloy (Py) layers, Py/Cu/Py and Co/Cu multilayers. The four-lead setup consists of four Cu strips forming a square of 3 to 5 mm each side. This setup allows us to perform both Hall effect and magnetoresistance measurements. Magnetoresistance measurements were performed with the magnetic field in the film plane (IP) for three situations: current parallel to field, current transversal to field and cross configuration like in [1]. Hall effect measurements were performed with the magnetic field perpendicular to the film plane (OP) and with the field misaligned (Δθ up to 15 ° of normal).

The small in-plane field component induces an abnormal behavior of the Hall voltage because of the in plane anisotropic magnetoresistance (AMR). The misaligned field produces a more rapid increases and saturation of the observed Hall voltage. For a thin film of Py (12 nm) the saturation field drops from about 7 kOe at Δθ=0 to about 2 kOe for Δθ=2.5 °. Considering the effect of the AMR we calculate the real values of the Hall voltages and compare them with the Hall voltage at Δθ=0. We discuss some possible applications for magnetic sensors.

[1] C. Prados, et al. Appl. Phys. Lett. **67** (1995) 718

We-PA047

SPIN DYNAMICS IN THE GENERALIZED FERROMAGNETIC KONDO MODEL FOR MANGANITES

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Dynamic spin susceptibility is calculated in the ferromagnetic state of the generalized ferromagnetic (FM) Kondo lattice model taking into account strong on-site correlations between e_g electrons and antiferromagnetic (AFM) exchange between t_{2g} electrons.
Our study suggests that competing FM double-exchange and AFM super-exchange interaction lead to a rather nontrivial spin-wave spectrum. While spin excitations have a conventional Dq^2 spectrum in the long-wavelength limit, there is a strong deviation from the spin-wave spectrum of the isotropic Heisenberg model close to the zone boundary.
The relevance of our results to experimental data are discussed.

We-Pa048

INFLUENCE OF HIGHLY ORIENTED LAYER AND THEIR ANITFERROMAGNETIC COUPLING IN GMR

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Antiferromagnetically coupled thin films have been studied because of their high potential for the application such as giant magnetoresistance (GMR) sensor from the past decade. The GMR effect was known to be originated from the scattering of polarized electrons at the interface. However, effect of roughness at the interface was not completely understood.
In this work, we studied $[NiFe/Cu]_2$ thin films which were epitaxially grown on HF-treated Si (002) substrates by DC sputtering method. Excellent epitaxial growth could be confirmed by (002) satellite peaks of $[NiFe/Cu]_2$ thin film. With varying Cu spacer thickness, maximum GMR value of 0.43 % in Cu spacer thickness of 25 Å was obtained under magnetic field of 100 Oe. However, non HF-treated $[NiFe/Cu]_2$ films showed low value of 0.09 %. No difference in M-H loops of both films was shown. In ferromagnetic resonance (FMR) experiment there were two absorption lines in both films. However, line width of HF-treated films was smaller than that of non-treated films. Larger line width indicates less homogeneity of magnetic phase. Magnetic homogeneity in this kind of film becomes worse due to pin holes and inter-diffusion between NiFe and Cu layer. Inter-diffusion and/or pin hole could be thought by one absorption line of single NiFe film on Si (100) and two lines in NiFe/Cu films.

We-PA049

BOSE VERSION OF THE DOUBLE-EXCHANGE IN THE MODEL MANGANITE.

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We develop the model description of the doped manganites ($La^{3+}_{1-x}Ca^{2+}_{x}MnO_3$, $La^{3+}_{1-x}Ce^{4+}_{x}MnO_3, \ldots$) as systems with instability to disproportionation reaction $MnO_6^{9-} + MnO_6^{9-} \to MnO_6^{10-} + MnO_6^{8-}$ with formation of the electron MnO_6^{10-} centers and hole centers MnO_6^{8-}. As a result, within a simplified model the doped manganite is equivalent to a system of triplet local bosons (spin $S = 1$, charge $q = 2e$), moving on the lattice of the effective hole centers with the orbitally non-degenerated $^4A_{2g}$ ground state and the on-site Hund rule, resulting in $^6A_{1g}$ state for the electron center. An effective Hamiltonian for such a system is the Bose version of the double-exchange Hamiltonian

$$\hat{H} = -\sum_{ij} \tau_{ij} \vec{T}_i^{\dagger} \vec{T}_j + \sum_{ij} V_{ij} N_i N_j + \mu \sum_i N_i - \tfrac{1}{2} \sum_{ij} J_{ij}^{hh} \bar{S}_i \bar{S}_j - \tfrac{1}{2} \sum_{ij} J_{ij}^{bb} N_i N_j \bar{s}_i \bar{s}_j - \sum_{ij} J_{ij}^{bh} N_i \bar{s}_i \bar{S}_j \, .$$

The first term in H corresponds to the boson kinetic energy with τ_{ij} being the transfer integral, the second one accounts for the Coulomb repulsion ($V_{ij} > 0$) of the bosons, located on the neighboring sites, we consider it to be effectively screened and short-ranged. The last terms describe exchange interaction between the hole centers and the bosons.

In terms of the mean-field approximation we have derived appropriate phase diagrams and the temperature dependencies of the order parameters for different phases including charge order, ferro- and antiferromagnetic, bose-superfluid (superconducting) and hybrid phases. Comparison with experiment implies first of all a careful taking account of inhomogeneity as important intrinsic property of these strongly correlated oxides.

We-PA050

TEMPERATURE DEPENDENCE OF MAGNETOIMPEDANCE EFFECT IN $Fe_{83}B_9Nb_7Cu_1$ ALLOY

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The temperature dependence of the magnetoimpedance(MI) in the $Fe_{83}B_9Nb_7Cu_1$ nanocrystalline alloy from 10K to 300K has been measured to investigate the influence of the structural changes in the nanocrystallization process as well as the changes of magnetic properties as a function of temperature. The MI measurements were carried out along the ribbon axis with longitudinal magnetic field. The nanocrystalline $Fe_{83}B_9Nb_7Cu_1$ alloy was prepared by the single roll rapid quenching method at Ar atmosphere. The sample was cut out 15 mm in length and 1.5 mm in width with 20 μm in thickness for the MI measurement. The frequency of the MI measurement was ranged from 1MHz to 10 MHz, and the current was changed from 10 mA to 50 mA for all measurements. The MI ratio was revealed the drastic increment as a function of $\exp(cT^2)$ where c is a constant. The measured MI ratio at room temperature is usually 2-3 times larger than the data measured at 10K. The changes of the incremental permeability as a function of an external field were also obtained using the MI measurement system. The MI ratio coincides with the softness of magnetic properties in annealed samples as well as the giant changes of the incremental permeability ratio as a function of the external field.

We-PA051
MAGNETOIMPEDANCE EFFECT IN MUMETAL THIN FILMS

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Magnetoimpedance (MI) effect in mumetal thin films has been investigated. Mumetal is known as a permalloy based material where Mo and Cu are added to improve the softness of magnetic properties. We have prepared mumetal films by using the RF magnetron sputtering method. Mumetal films with 17 mm in diameter and 1~4 μm in thickness were deposited on a glass substrate. The coercivities and effective permeabilities of the films were proportional to their thickness. The composition of the softest film is $Ni_{81.1}Fe_{14.2}Cu_{1.9}Mo_{2.8}$ (wt %). The MI was measured with strip type samples with 15 mm in length and 2 mm in width prepared by using the lithographic method. The giant magnetoimpedance of the film was reached as much as 81% at 36.5 MHz. The transverse incremental permeability ratio (TPR) and the MI ratio (MIR) as a function of an external field show the double peak patterns due to the transverse easy axis, and the single peak patterns in the case of the longitudinal easy axis in the film. The magnetic anisotropy was controlled by a rapid thermal annealing (RTA) method with an uniaxial external field.

We-PA052
THE *s-d* MODEL OF ELECTRON TUNNELING BETWEEN METALLIC FERROMAGNETIC LAYERS

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From theoretical point of view, we have investigated the transport properties in metal/oxide multilayer nanostructures of the form F/O/F where F represent ferromagnetic electrodes and O is an oxide isolating layer. For qualitative description of the influence of true band structure of transition 3-*d* metals onto the magnetotransport properties, we have worked out two-band *s-d* model for electron tunneling, paying particular attention to the differences in mechanisms of tunneling for the electrons from *s* and *d* subbands. The conductivity and magnetoresistance (MR) of the system were calculated using Kubo formalism of linear response and Green's function method in the mixed real-space-momentum representation. Analytical calculations were carried out under the assumption of free-electron gas in metal layers both for *s* and *d* electrons taking into account the splitting of spin-up and spin-down electron bands. The coherent potential approximation (CPA) was used to investigate the contribution of spin-dependent interfacial scattering on impurities and magnons on MR effect. Two contributions to the tunnel current and to the MR were obtained: one corresponds to the "bubble" diagram for conductivity and is a generalization of Slonczewski formula for two-band model, the other arises due to vertex correction for conductivity and is responsible for tunneling assisted by interfacial scattering. It has been calculated in the ladder approximation combined with the CPA and gives substantial contribution to the total tunnel conductivity.

We-PA053

EIECTROMAGNETIC PROPERTIES OF THE TUNNEL SIS JUNCTION

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The calculation of the current-voltage characteristic and description of the corresponding fluxon dynamic of the long Josephson tunnel junction (superconductor-insulator-superconductor (SIS)) with homogeneously injected currents in an external magnetic fields are done in terms of periodic solitons. The superconducting phase difference and penetration of magnetic field in the tunnel barrier are described with help of the ``sine-Gordon'' equation which is perturbed by a small energy dissipation of the quasiparticle tunnel current. On the basis of the asymptotic theory of weakly perturbed integrable nonlinear equations we obtain expressions for the phase difference in the form of theta functions with parameters which change slowly in respect to the time and space variables. This slow change is described by the Whitham equations resulting from the condition of the balance between the injected and dissipation energies. Using the kink-kink two-gap solutions for the phase difference we have calculated the expressions for the injected current and the voltage of the junction in the terms of the Riemann theta functions. We describe the current-voltage I(V) curve in the parametric form in terms of the two-dimensional Riemann matrix (τ) which characterizes the theta function. The component τ_{11} of the matrix is a parameter of the I(V) dependence and the two other components τ_{22} and τ_2 are determined by periodis of the junction and the wave length. If these periods are commensurable then the appropriate Riemann matrix is reducible that leads to singularities in the current-voltage characteristic. Thus we have shown that the I(V) dependence consists of the system of monotone increasing curves with a number of resonance peaks modulated by the magnetic field. In comparison with previous results the current-voltage is general and valid for all magnetic fields.

We-PA054

NON-VALENT ORBITAL BONDS IN Fe-Co ALLOYS

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In his book [1] R. Bozorth with bewilderment tells about presence of minimum on the graph of resistivity concentration dependence of BCC Fe-Co alloys that falls on 50 Fe-50 Co alloy. This minimum can not be removed by hardening or by annealing [2]. The nature of this minimum we associate with the presence in this alloys some interatomic bonds, that chemists call non-valent orbital bonds.

Minimum of such bonds falls on 50 Fe-50 Co alloy. Analogous to the true covalent bonds non-valent orbital bonds create some localization of conductivity electrons and, therefore, ρ increasing. We see the influence of non-valent orbital bonds on properties of alloys in the next experimental facts.

1) They prevent atomic ordering. The corresponding supper-lattice because of them in bulk samples of 75 Fe-25 Co alloy in a number of works was not discovered.
2) The big uniaxial anisotropy is induced in alloys close to this composition both in bulk and in film samples, the value of which connected with value K_1 magnetocrystalline anisotropy.
3) There exists a correlation between the graph of $\rho(c)$ and the graph of concentration dependence of the thermal expansion coefficient (α) BCC Fe-Co alloys.

There is a grounding to consider that non-valent orbital bonds exist in metallic Fe.

[1] R.M. Bozorth. // Ferromagnetism, 1951.
[2] T.V. Pshechenkova, A.D. Skokov. // Book of manuscripts: The ordering of atoms and their influence on properties of alloys. Kiev, 1968, p.225.

We-PA055
MAGNETO-OPTIC PERIODIC STRUCTURES

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The interest in the magnetic layered systems has exhibited increasing tendency in the last decade. The attention, traditionally focused on the ultrathin magnetic layers, is shifted now to the 2D periodic structures. Experimental study of optical wave diffraction was carried out in 1D surface relief grating structures covered by magneto-optic material [1]. Recently, the progress of technology allowed to form bi-periodic 2D structures. A typical example can be represented by double periodic array of ferromagnetic metal dots exhibiting magneto-optic response [2]. The contribution is devoted to the study of magneto-optic 2D structure. Theoretical description uses coupled wave approach based on the assumption, that the electromagnetic field in the structure can be expanded into a Fourier series with the same period as is the period of the Fourier expansion representing the space distribution of material parameters. Because the structure contains lossy media (ferromagnetic dots), special attention is paid to the boundary condition formulation. The experimental part is devoted to the measurements of the light reflection from Fe/Cr superlattice series on single-crystal MgO substrate with various strip geometries.

[1] Gadetzky S., Syrgabayev I, Erwin J. K., Mansuripur M., Suzuki T. and Ruane M. // J. Opt. Soc. Am. A13, (1996), p. 314
[2] Bardou N., Bartenlian B., Rousseau F., Decanini D., Carcenac F., Chappert C., Veillet P., Beauvillain P., Megy R., Suzuki Y. and Ferre J. // J. Magn. Magn. Mater., 121, (1995), p.293

We-PA056
MAGNETO-OPTICAL PROPERTIES OF ORTHOFERRITE THIN FILMS

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This study reports on the magneto-optical properties of rare-earth orthoferrite thin films produced by pulsed laser deposition. Orthoferrites are known to exhibit a spin reorientation transitions (SRT) at low temperatures except for $SmFeO_3$ where this transition occurs at about 470K. Faraday rotation (Θ_F) measurements have been performed on films of $YFeO_3$, $DyFeO_3$ and $SmFeO_3$ to study the high temperature magneto-optical properties (290K to 750 K). To first order Θ_F is proportional to the magnetisation (M), therefore Θ_F should decrease continuously to zero with M as the temperature reaches the Curie temperature. However, thin films of $SmFeO_3$ and $DyFeO_3$ show an unexpected increase of Θ_F and exhibit a maximum at about 530K and 470K, respectively. As the maximum in Θ_F is observed in both $SmFeO_3$ and $DyFeO_3$ and only $SmFeO_3$ shows this SRT in the same T range, it can be assumed that the SRT is not at the origin of the Θ_F maximum. Also $YFeO_3$ thin films present an anomalous T dependence of Θ_F. The Faraday rotation first decreases to zero and than exhibits a very pronounced maximum at 620K. This behaviour is not understood yet. However, differences in the electronic configuration of the RE atoms can be stated (empty 5d shell for $DyFeO_3$ and $SmFeO_3$, 1 unpaired 4d electron for $YFeO_3$) which may help to understand the phenomena.

We-PA057

YIG THIN FILMS PREPARED BY PULSED LASER DEPOSITION : STRUCTURAL, MAGNETIC AND MAGNETOOPTIC PROPERTIES

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Recently much attention has been paid to the surface effects in ultrathin ferromagnetic metallic films. It is interesting to study the same kind of effects in ferrimagnetic oxides. Physical properties of one of them, bulk yttrium iron garnet (YIG), are well known and can be easily compared with those of thin films. We therefore use this model material to grow thin and ultrathin films, where we expect to observe changes in magnetic properties due to surface effects. This is our first report on the preparation of the very thin YIG films (300-4000 Å) on quartz substrates by the pulsed laser deposition (PLD) technique. The conditions of growth of well-formed polycrystalline and slightly textured films have been determined. We found also that the size of the unit cell of YIG depends on the partial pressure of oxygen. The Faraday rotation of these films correspond to that of bulk material, and their average saturation magnetization is slightly inferior to the bulk value. The Curie temperatures have been measured to be the same as for bulk YIG crystals. Some ultrathin films with thickness about 80-300 Å were deposited. The dependence of their magnetic moment on the temperature was measured in SQUID at T=5...300K and then extrapolated to the region of higher temperatures. The extrapolated Curie temperature of these ultrathin films are reduced compared to that of bulk YIG.

We-PA058

DESCRIPTION OF LIGHT PULSES INDUCED CHANGES OF MAGNETIC ANISOTROPY IN YIG:Co

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Polarized light induced changes of volumes of magnetic domain phases with different in plane magnetization components were observed in YIG:Co film grown on (001) plane of GGG substrate. The photomagnetic effect was observed from about 150K up to room temperature [1] and were explained as light induced changes of magnetic anisotropy. Dynamics of the effect was investigated using linearly polarized argon laser beam (λ= 488 nm) in pulse regime using Pockels cell. Different times characterizing photoinduced uniaxial anisotropy respectively creation and vanishing were deduced from these experiments. The difference changed in temperature function. Theoretical model was proposed for the magnetic anisotropy description taking into consideration existence of Co^{2+} ions in octahedral positions. Probability of both isotropic thermal and anisotropic polarized light induced excitations of these ions were included in constructed equations. Their analytical and numerical solutions gave information about dynamics of Co^{2+} ions redistribution and afterwards light induced changes of both uniaxial and cubic anisotropies. The proposed model well describes experimental results.

[1] Chizhik A.B., Davidenko I.I., Maziewski A., Stupakiewicz A. // Phys. Rev. B, **57**, 21 (1998), p.14366.

We-PA059
PHOTOINDUCED CHANGES OF MAGNETIZATION CURVES AND OF DOMAIN STRUCTURE IN YIG:Co

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Photomagnetic effects induced by linearly polarized He-Ne laser beam were investigated in YIG:Co films grown by liquid phase epitaxy on the (001) plane of GGG substrate. Preliminary investigations showed peculiarities of light induced effects - photoinduced linear birefrigence. at about 20K. The present study was performed in a macroscopic area of the sample using magnetic circular dichroism MCD. Magnetic domain structures were visualized using low power halogen lamp by means of a magneto-optical Faraday microscopy technique supported by digital images processing. The photomagnetic effects (light induced changes of magnetization curves, creation of magnetic domain phases,..) were observed within the range from 10K up to room temperature. Temperature induced easy magnetization axis reorientations were deduced from torque magnetometry measurements made at the range. Results of magnetooptical study are explained taking into consideration light induced magnetization reorientations. Photomagnetic effects are connected with huge cobalt ions contribution to magnetic anisotropy. Contribution of Co ions in tetrahedral sides is especially important for photomagnetism in YIG:Co at temperatures below about 120K.
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We-PA060
MAGNETO-OPTICAL KERR SPECTROSCOPY OF Pd AND Pt

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We present magneto-optical Kerr effect (MOKE) spectra of the paramagnetic fcc Pd and Pt metal films measured in the applied magnetic field of 1.5 T over the photon energy range 0.8-4.8 eV. *Ab initio* calculations performed using spin-polarized fully relativistic LMTO method reproduce well the experimental spectra and explain the microscopic origin of the magneto-optical (MO) response in terms of individual interband transitions. The band-by-band decomposition of the MO spectra allows to identify the transitions responsible for the prominent structures in the spectra and to show an important role of the transitions from the states in the vicinity of the Fermi level in the formation of the MO spectra. The effect of the intraband contribution to the off-diagonal optical conductivity on the MOKE spectra is discussed.
The calculations show that the proportionality between the magnitude of the MOKE spectra and the magnetic moment induced on the Pd or Pt atoms holds up to the value of $\approx 0.25\ \mu_B$ typical for magnetic Pd compounds. It is shown that in spite of the different mechanisms of the Pd (Pt) magnetization, the spectral dependence of the MOKE of the paramagnetic Pd and Pt metals measured in the external magnetic field is similar to that of ferromagnetic Pd (Pt)- rich alloys with magnetic $3d$ metals.

We-PA061

MAGNETO-OPTICAL INVESTIGATION OF H-T PHASE DIAGRAMM IN Fe/Si MULTILAYERS

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The process of magnetic field induced phase transition from collinear to noncollinear spin configurations has been investigated in Fe/Si multilayered films in the temperature range 20-300K. The (Fe30Å/Si15Å)x11 multilayers were prepared by dc sputtering. The magnetization reversal was studied using the magneto-optical Kerr effect. The ferromagnetic resonance measurements have shown the presence of cubic anisotropy in the plane of the film. The magnetic field was applied in the film plane along the hard axis. At room temperature the field dependencies of Kerr rotation demonstrated the features associated with the phase transition from collinear antiparallel to noncollinear structure. With the temperature decrease the value of the phase transition field decreases. Below 170K, when the noncollinear structure becomes stable in zero magnetic field, this phase transition was not observed. Also the value of the transition field from noncollinear to collinear parallel structure have been obtained. Numerically calculated H-T phase diagram has been constructed using the theory [1], which takes into account the competition between bilinear and biquadratic exchange and cubic magnetic anisotropy, and the change of the relation between bilinear and biquadratic exchange with temperature. The calculations demonstrate good agreement with experimental data.

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We-PA062

OPTICAL AND MAGNETOOPTICAL PROPERTIES OF Fe/Cu MULTILAYER STRUCTURES WITH ULTRATHIN LAYERS

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The spectral (λ=0.3-2.5 μm) dependences of diagonal ε_{xx} and off-diagonal ε_{xy} components of effective dielectric tensor of Fe/Cu multilayers with the layer thicknesses t_{Fe}=(5-20)Å and t_{Cu}=(0.9-14.4)Å have been studied by ellipsometry and equatorial Kerr effect (EKE).
The samples were prepared by rf-sputtering onto Si(100) substrates in an argon atmosphere and certified by X-ray diffraction for phase structure.
We have shown, that the EKE dependence on Fe relative content of the multilayers shows a sharp kink at t_{Cu}=3.6Å (2ML). That indicates of being this thickness a critical one in the process of ferromagnetic γ-Fe phase forming.
On the basis of the optical and magnetooptical data analysis it has come to the conclusion that $\alpha \to \gamma$ transformation in Fe layers effects on the electron energy spectrum close by Fermi level and on the effective dielectric tensor of Fe/Cu.
It has been established, that the field dependence curves of EKE (H<10kOe) for Fe5Å/Cu(t) (t=0.9-7.5Å) appear as a typical one for multilayer periodic structure with non-collinear magnetic ordering.

We-Pa063

QUANTUM OSCILLATIONS OF OPTICAL CONDUCTIVITY AND MAGNETOOPTICAL KERR EFFECT IN Fe/GaAs/Fe SANDWICHES

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The possibility of exchange coupling between ferromagnetic layers, separated by a nonmetallic spacer layer, has been predicted theoretically in [1]. Recently the antiferromagnetic exchange coupling was discovered in sandwiches of Fe with amorphous Si, Ge, and ZnSe [2].

We have studied optical and magnetooptical properties of Fe/GaAs/Fe sandwiches in the spectral range $\hbar\omega$=0.5-5 eV by ellipsometry and equatorial Kerr effect (EKE, δ_p-effect). Samples with a constant Fe layer thickness (t_{Fe}=15 or 30Å) and variable thickness of amorphous GaAs layer (t_{GaAs}=6-26Å) have been prepared by rf-sputtering onto Si(100) substrates at room temperature.

It has been found, that the dependences of the effective optical conductivity and EKE on GaAs layer thickness appeared as non-periodic oscillations. The Fourier analysis of $\delta_p(t_{GaAs})$ curves shows dominant role of harmonics with periods of ~2Å and 5Å.

The relative contributions of ε_{xx} and ε_{xy} to oscillation behavior of δ_p-effect are analysed. The data of the field dependence of EKE ($H\leq$10kOe) don't allow us to make the conclusion about the existence of interlayer Fe-Fe exchange coupling through amorphous GaAs layer.

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[2] Walser P., Hunziker M., and Landolt M.//JMMM, 200, (1999), p.95.

We-PA064

MAGNETO-OPTICAL INVESTIGATION OF Fe/Pt THIN-FILM STRUCTURES

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Results on the investigation of magnetic and magneto-optical properties Fe/Pt/Fe trilayers and sandwiches with wedge-shaped Fe and Pt layers are presented. The measurements were carried out employing the magneto-optical spectrometer and the magneto-optical micro-magnetometer by means of transverse Kerr effect (TKE). In the trilayers the Fe-film and Pt-layer thickness was varied from 2.5 to 10 nm and from 0.4 to 4 nm, respectively. The slopes of Pt- and Fe-wedges were equal to 0.35 and 0.3 nm/mm, respectively. Their lengths were equal to 20 mm. By scanning the light spot of 0.03-mm diameter along the wedge length, the dependence of TKE on the wedge thickness were found. The spectral dependencies of TKE for the studied samples were measured in the photon energy range from 1.6 to 4.5 eV. The strong influence of the Pt-layer on properties of the examined thin-film structures was discovered. It was established that the saturation field of trilayers oscillates as a function of the Pt-layer thickness (t_{Pt}) and a period of these oscillations depends on Fe-film thickness. The obtained data were explained by the presence of the exchange coupling between Fe-layers and its oscillatory behavior with changing t_{Pt}. It was discovered that in the sandwiches TKE oscillates along Pt-thickness periodically. The period of the oscillations is equal to ~1.0 nm. The strong Pt layer influence on TKE spectra of the samples was revealed. TKE magnitudes decrease with increasing t_{Pt}. It was established that the Pt-layer exerted an influence upon the magneto-optical properties of the studied samples more significantly in the ultraviolet photon energy range. The discovered peculiarities of magnetic and magneto-optical properties of Fe/Pt thin-film structures were ascribed to the spin-polarized Quantum Well States in the Pt-layer.

We-PA065
ELLIPSOMETRICAL METHODS OF THE MEASUREMENTS OF THE MAGNETO-OPTICAL PARAMETER

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In our recent paper [1] is shown that the simultaneous measurements of the optical constants N= n-ik and the magneto-optical parameter $Q=Q_1-iQ_2$ of ferromagnetic are possible. The angle of the incidence of the light is fixed and the equatorial Kerr effect geometry is used. Thus, the magnetization orientation is perpendicular to the plane of light incidence. Because of the smallness of the magneto-optical parameter, $|Q|<<1$, the basic ellipsometrical radio, as well as the detected signals, contains two independent parts. One of them is optical part, and the other is the magneto-optical one. If not only the magnetization is changed, but the polarization of the incident light also, then the Fourier-analyse is performed. These methods considerably simplify the consideration of the magneto-optical interference contribution on for the case of the thin magnetic films.

[1] Bakradze O. I. // J. of opt., N5, v.66, (1999), p.73

We-PA066
MAGNETO-OPTICAL INFORMATION MEDIUM

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With a view to creating magneto-optical information media for laser CDs, a technique has been developed to make thin amorphous magneto-optical films out of rare earth and transition metal alloys with perpendicular anisotropy, high values of magneto-optical rotation angles, and signal/noise ratios. Density of the information recorded on the samples obtained using the developed method is up to 10^7-10^8 byte/cm^2. The information was recorded using a thermomagnetic method, while to read out the information Faraday and Kerr magneto-optical effects were employed.
A method for creating magnetic films with perpendicular anisotropy has been developed on the basis of investigating the dynamics of Hall effect in the process of growth of the films using the internal magnetic field of the film. The method permits to increase the share of film fit for information recording up to 100%.
A possibility has been studied for over-writing information on the magneto-optical disk without deleting the previously stored information, which will allow to decrease twice the recording time, as well as significantly simplify the configuration of the recording device.

We-PA067
PHOTOMAGNETIC EFFECTS IN GARNETS UNDER AN INFLUENCE OF ELIPTICALLY POLARIZED LIGHT

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In accordance to the modern conceptions the nature of photoinduced magnetic effects in magnetically ordered mediums is connected with photoinduced charge transfer between magnetic anisotropic impurity centers localized in crystal sites with different environment symmetry. Electron transitions between magnetic anisotropic impurity centers under the influence of elliptically polarized light are considered at the present work for the first time. The theoretical model of the occupancies kinetics of such centers localized on octahedral sites of garnet lattice was developed. Spatially inhomogeneous distribution of the energy of photoinduced magnetic anisotropy was calculated in the sample being illuminated with light with modulated polarization. Considered conditions could be realized during the sample illumination with two linearly polarized coherent optical beams. Basing on the analysis of known experimental results for epitaxial films of Co doped yttrium iron garnet it was ascertained that obtained energetic relief of photoinduced magnetic anisotropy is sufficient for the formation and stabilization of stripe magnetic domain structure. A conclusion about a possibility of recording of holographic magnetic gratings in the investigated materials was made depending on results obtained.

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We-PA068
THE MAGNETOOPTICAL INVESTIGATION OF METAL-GLASS TRANSITION REGION IN AMORPHOUS MAGNETIC MICROWIRES.

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The results of magnetooptical investigation of metal-glass transition region of amorphous magnetic microwires in wide range of energy of incident light ($\hbar\omega=1\div5$ eV) were considered.
We have investigated microwires of $Co_{81.73}B_{3.36}Si_{5.81}Mn_{9.1}$, $Fe_{75}B_{15}Si_{10}$, $Fe_{88.2}B_{1.4}Si_{6.4}C_4$ and $Fe_{94.5}B_{2.5}C_3$ with different diameters of metallic core and different thicknesses of glass cover.
The obtained experimental dependences of the equatorial Kerr effect were analysed by means of optical model in which the influence of two light rays is considered. The first ray reflects from the glass cover of microwire, and the second ray – from the metallic core.
It was found that the surface region of roentgenoamorphous microwire can be amorphous or nanocristallic or granular in dependence of metallic core diameter. Also the influence of composition on the amorphization of metallic core was found.
The properties of the transitional layer which appears between metallic core and glass cover differ from metal and glass properties. This transitional layer changes the behavior of magnetooptical interference in ultra-violet region of spectrum.

We-PA069

POLARIZATION–DEPENDENT PHOTOINDUCED CHANGE OF MAGNETIC STATE IN $\alpha-Fe_2O_3$: Ga, Yb CRYSTALS

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The number of magnets, having polarization-dependent photomagnetic effect, is limited by MnF_2, $Y_3Fe_5O_{12}$:Si, $Ca_3Mn_2Ge_3O_{12}$ and the search of new photosensing materials in this direction proceeds. By method of the antiferromagnetic resonance (AFMR) it was revealed by us that the weak ferromagnetic crystals α-Fe_2O_3:Ga with Yb rare earth ions exhibit the polarization-dependent change of magnetic properties.
In the present case the effect takes place in temperature range T< 130 K. Distinctive feature (from the other crystals) is the dependence of the AFMR width line on polarization of optical radiation and change of sign of the resonance field shift (δH_r) with the change of the polarization of the optical radiation. The values of photoinduced shifts of the resonance field for different polarizations of optical radiation depend on the direction of the magnetic field in the crystal basal plane. The irradiation by the light with the polarization E || H always increases the value of the resonance field and with polarization E ⊥ H reduces it. For the polarization E || H the value of effect is maximum for the magnetic field along the direction of hard magnetization. In the present case there is the most probably the formation of a defect of the anion vacancy type and the ytterbium ions located near. . Thus, as a result of irradiation the transformation of the photocentre can be of the type $2Yb^{2+} + \boxed{O^{2-}} \underset{\longleftarrow}{\overset{\longrightarrow}{h\nu}} Yb^{3+} + Yb^{2+} + F'$.

We-PA070

MAGNETOOPTIC ACTIVITY OF RE-DOPED OXIDE GLASSES.

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Faraday rotation (FR) and optical absorption (OA) of different oxide glasses, activated by Pr and Dy are investigated in spectral region 220-2200nm. Magnetooptical activity (MOA) for f-d and some f-f electron transitions are calculated on the base on the FR and OA measurements. It is shown that MOA depends on the glass matrix composition and, as the rule, it is higher for f-d in comparison with f-f transitions. For f-f transitions MOA can differ in several order of value for some of them it can reach value close to the MOA of f-d transition. For example, in new glass system $LiB_3O_5+Pr_2O_3$ MOA is equal to: $7.7{\cdot}10^{-6}$ for f-d transition and $1.2{\cdot}10^{-6}$, $9.3{\cdot}10^{-7}$, $3.3{\cdot}10^{-8}$ and $5.9{\cdot}10^{-7}$ min·mol·cm· $\ell^{-1}{\cdot}Oe^{-1}$ for the $^3H_4{\to}^3P_2$, $^3H_4{\to}^1D_2$ and $^3H_4{\to}^1G_4$ $^3H_4{\to}^3F_3$ transitions, correspondingly. At same time the MOA of the last transition in Pr in the silico-phosphate matrix is equal to $1.9{\cdot}10^{-6}$ min·mol·cm· $\ell^{-1}{\cdot}Oe^{-1}$.
The dependence of the f-f transition MOA on the rare earth surrounding and transition type is discussed.
The work is supported partly by the Russian Foundation for Basic Research (Grant no. 99-0217375).

We-PA071

SPIN-REORIENTATION PHASE TRANSITIONS INDUCED BY POLARIZED LIGHT

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The effect of polarized light on magnetic characteristics of the films with a strong mutual influence of magnetic and electronic subsystems were reported early. At first such effects were observed at room temperature in doped ferrite-garnet films. But soon it was shown the possibility of reversal influence of light on some other substances in the vicinity of the phase instability state, e.g. CMR manganites, doped fullerenes, etc.

We have studied light induced effects magneto-optically using of Faraday and Kerr- magnetometers with high resolution. The investigated structures were 2-layered ferrite-garnet films doped with Tu and Lu, and formed by annealing in air at 1100 C of the films with in-plane anisotropy. One of the layers (rigid) became perpendicularly anisotropic and another (soft) remained in-plane anisotropic. In such a film light induced changes of the soft layer domain structure caused changes in the domain state of the second layer. Magneto-optical method allowed to determine characteristics of the internal transitional sublayer between two main layers.

The similar effects of light influence on magnetic state can be also observed in film manganites $La_{0.7}Sr_{0.3}MnO_3$ as well as in composites on the base of fullerenes C_{60} doped with Fe_2O_3. In the first case the distribution of magnetization on the film surface were studied by MOKE in a temperature range 77-370 K. The observed changes of hysteresis loops in the vicinity of maximum CMR depended on intensity and polarization of irradiated light. In the second case the above mentioned two-layered garnet film was used as a probe for image the surface magnetization of almost non-refractive bulk fullerenes.

We-PA072

MAGNETOOPTICAL SPECTROSCOPY OF 4f → 4f -RADIATIVE TRANSITION IN $Y_3Al_5O_{12}$: R^{3+} (R=Tb, Er)

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Magnetocircular polarization of luminescence (MCPL) in $Y_3Al_5O_{12}$ containing threvalent rare-earth (RE) ions Tb and Er has been investigated in range of wavelength 450-650 nm at T=85-300K. MCPL i.e. circular anisotropy of secondary emission spectra in a magnetic field H caused by polarization of Zeeman components of luminescence lines corresponding to the radiative 4f – 4f transition appearing in $Y_3Al_5O_{12}$:R^{3+} garnets. It is discovered that, MCPL degree $P = (I_+ - I_-)/ (I_+ + I_-)$, where $I_\pm$ are the intensities of clockwise and conterclockwise polarized luminescence components for a number of radiative transitions can reached giant values (P ~ 30% at T=85K, H=10kOe). The behavior of features of MCPL degree spectra on the investigated crystals has been interpreted in view of the microscopic theory which takes into account the structure of the energy spectrum fop a RE in garnet, and mechanism "mixing" of electronic states of RE ion in field H.

We-PA073
GARNET FILM TRANSFORMERS FOR SIGNALOGRAM ANALYSIS

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Magneto-optic (MO) method of recorded signalogram stray field visualization is based on film converters which functional advantages are conditioned by Faraday effect in Bi-substituted epitaxial garnet films (EGF) [1].
As a rule "bubble" EGF with binary stripe domains are used, but we have succeeded in the development of high-sensitive "faceted" EGF and "easy plane" anisotropy films for expansion of MO method capabilities to make possible composite signalogram analysis. "Faceted" EGF must be heated up to Curie temperature T_C by "contact printing"; operative analog type visualization can be obtain with the "easy plane" anisotropy films [2].
All film specimens were prepared by means of liquid-phase epitaxial growth. Base compositions were $(Bi,Lu,Ca)_3(Fe,Ge)_5O_{12}$ for "easy plane" EGF and for "faceted" films - $(Bi,Lu,Sm)_3(Fe,Ga,Al)_5O_{12}$. Using the films we obtained spatial resolution about 1000 lines/mm and sensitivity ~0.1 Oe. Our experiments demonstrated fine possibilities of MO EGF in loss data restoration. We obtained an aircraft "black box" signalograms from the tape heated up to 500 °C.

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[2] Vishnevski V., Dubinko S., Nedviga A., Prokopov A., Groshenko N. // Int. Conf. on Ferrites ICF7, Bordeaux, France: Proc., (1996), p.76.

We-PA074
ANOMALOUS BEHAVIOUR OF FARADAY ROTATION AND OPTICAL PROPERTIES OF Co-Fe-Hf-O MAGNETIC GRANULAR FILMS

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Granular films of composition $(CoFe)_x(HfO_2)_{1-x}$ with continuous variation of the $Co_{0.5}Fe_{0.5}$ volume fraction in the range $0.1 < x < 1$ have been prepared by e-beam co-evaporation.
The optical properties of the films have been determined from transmission and reflection spectra in the 300-1100 nm region. The optical characteristics of the films as a function of x were also determined by the ellipsometrical method at $\lambda = 632.8$ nm and $\lambda = 830$ nm. The Faraday rotation in the films was determined at $\lambda = 632.8$ nm. We find that the transmission and reflection spectra and the dielectric function have anomalies near the percolation threshold at $x \approx 0.45$. The spectral dispersion of Faraday effects has peak in the region of the plasma frequency. The Faraday effect is greatly enhanced near x_p. We also find that the extraordinary Hall resistivity, measured at room temperature and at 8 kOe of applied field, increases dramatically from 0.2 to about 600 μΩ cm near the percolation threshold. These films also possess large magnetoresistance, whose values are about 6 % in maximum for x=0.35–0.45.
The calculated optical and magneto-optical parameters and the extraordinary Hall resistivity, described in the framework of the effective medium approximation, are in qualitative agreement with experimental data.

We-PA075

THE INFLUENCE OF LOCALIZED ELECTRONIC STATES ON THE OPTICAL AND MAGNETO-OPTICAL PROPERTIES AND MAGNETORESISTANCE IN AMORPHOUS CoFeNiSiB ALLOYS.

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The optical and magneto-optical properties of amorphous CoFeSiB ribbons were investigated for incident photons in the energy range from 0.05 to 2.2 eV. The diagonal and off-diagonal optical conductivity were determined from the results of spectroscopic ellipsometry and magneto-optical Kerr effect measurements. The Kerr rotation spectra for the amorphous films have a shape in the 0.6 - 2.2 eV region that is quite similar to that of bulk Co. The optical conductivity of the amorphous CoFe(Ni)SiB alloys increases slowly as a function of frequency (proportional to $\omega^{1/3}$) in the IR region. Such a $\sigma \sim \omega^{1/3}$ dependence in the IR region suggests an additional localisation of the electron states. A large room-temperature magnetoresistance effect has been demonstrated in thin $Co_{71}Fe_7Si_{12}B_{10}$ and $Co_{59}Fe_5Ni_{10}Si_{11}B_{15}$ amorphous ribbons for ac current at applied fields, H,<80 Oe. The peak value of the magnetoresistance ratio is very sensitive to the Co and Fe concentration in the alloys. The dependence of the magnetoresistance for amorphous alloys is consistent with a theoretical model in which the resistivity arises from the scattering of the conduction electrons by a domain wall in the weakly localized regime.

We-PA-076

CHANGE OF GMR PARAMETERS IN N-ION IMPLANTED SPIN-VALVE

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The samples, NiO(30 nm)/NiFe(t nm)/Cu(4 nm)/NiFe(5 nm)/Ta(5 nm) films for t=3, 5, 7, and 9, are prepared by the rf-magnetron sputtering method. N-ion was implanted on the samples, where the fluences were 1×10^{16} ions/cm^2. The resistance was measured by the four probe method at measuring field angle $\theta = 0^\circ$ and 90° from the bias field. The GMR profiles for no N-ion implanted samples at $\theta = 90^\circ$ show typical MR characteristics with a dip due to AMR effect. The increasing MR ratio ($\Delta R/R$) with thickness t reaches to 4 % for t=7 nm sample.
The MR profiles in ion implanted samples show a dip in profile for $\theta = 0^\circ$ and the maximum value of MR ratio is reduced to 1.5 % in t=7 nm sample. The single dip of GMR profiles at $\theta = 90^\circ$ is nearly unchanged, however, the two broad peaks are more dominantly distorted. The implantation effect is become prominent as the t increases, indicating that the N-ion implantation causes the change of the intrinsic magnetic characteristics of pinned layer than free layer. In this paper, we present the change of GMR parameters as functions of the N-ion implantation and measuring temperature down to 10 K by the analysis of the results using double-domain model[1].

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We-PA077

EFFECT OF THIN FeNiMo LAYER ON MAGNETIC PROPERTIES OF FeCoV AND FeNi FILMS

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With the purpose of searching for relations between the magnetic interactions among magnetic films which have different magnetic properties and the soft magnetization of FeCoV film, it was confirmed that by being made into a multilayer film with a small quantity of FeNiMo layers (about 2% in volume) , the coercive force of FeCoV film becomes lesss than about 1/10 [1]. The same phenomenon was observed in Fe50Ni50 films. In this paper, the cause of drastic change of magnetization processes and decrease of coercive force due to thin FeNiMo layers is studied.
The features of magnetization processes of FeNiMo/FeCoV/FeNiMo and FeNiMo/FeNi films are investigated by observation of magnetization curves and magnetic domain structures. The reduction in coercive forces seems to be related to the magnetic anisotropy of magnetic layer which was evaporated firstly on the substrate. Thin FeNiMo layer with anisotropic magnetic properties leads the magnetic anisotropy in the semi-hard magnetic layer which originally does not have magnetic anisotropy and has the volume of about 100 times of very thin FeNiMo layers. The features of magnetization processes of FeNiMo/Fe/FeNiMo and FeNiMo/Co/FeNiMo are investigated also. In these cases, the change of magnetization processes and decrease of coercive force does not occur in these combinations. Examinations regarding substantial causes of effective interaction between very thin FeNiMo layer and semi-hard magnetic layers, such as effects of microstructure of films, will be invetigated.

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We-PA078

TECHNOLOGICAL FEATURES OF PERPENDICULAR ANISOTROPY FORMATION IN TbFe FILM

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Experimental investigations results of basic technological parameters (residual gases pressure, evaporation rate, composite atoms concentration and addition elements introduction, separate layers thickness in multilayered films) influence on perpendicular anisotropy of amorphous and multilayered TbFe films are given. Film were fabricated by a method of magnetron sputtering of one or two alloyed targets or by electron-beam evaporation from two crucibles. As addition elements Dy (0-50%), Gd (0-100%), and Co (0-50%) were used.
It is shown that to obtain amorphous TbFe films with a high level of perpendicular magnetization it is necessary to set concentration of atoms in them close to compensative $Tb_{22}Fe_{78}$ at a high evaporation rate. Replacement of terbium atoms by dysprosium or gadolinium atoms reduces the energy of perpendicular anisotropy, and gadolinium influences much more strongly. Introduction of cobalt atoms instead of iron atoms lightly influences on perpendicular anisotropy, but rises Curie temperature and increases films aging time. Films obtained by magnetron sputtering have rectangular back magnetization loops even at high temperatures and are more aging-resistant.
It is revealed that under the influence of powerful laser radiation the time of degradation of investigated films abruptly decreases. On the basis of obtained results it is concluded that the main factor in TbFe films perpendicular anisotropy is terbium atom electronic shell anisotropy.

We-PA079

MAGNETIC INTERACTIONS IN MBE GROWN Fe/Au/Tb TRILAYERS

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The nature of magnetic interactions at the rare earth/transition metal (RE/TM, in particular Tb/Fe) interface is not well agreed upon, whereas it is important from the physics as well as storage application points of view. The understanding of this interaction is further lacking for the case where a nonmagnetic metal layer is interposed between the magnetic layers. The present work is undertaken to systematically study this phenomenon, by carefully preparing samples under the cleanest condition with sharp and diffuse interfaces.
Using FMR, PMOKE and SQUID techniques, Fe(3ML)/xAu/Tb(3ML) trilayers grown in an MBE system were investigated. Without Au layer, perpendicular magnetic anisotropy was observed in Fe/Tb interface. Only one Au ML interposed between Fe and Tb layers was enough to shield the short-range magnetic interactions. Enhancement in magnetic moment and its variation as a function of Au thickness were observed. These experimental results will be discussed.

The work was supported by NSF Grant DMR 9730908 and NSF International Collaborative Grant 9940368.

We-PA080

FMR INVESTIGATION OF IN-PLANE ANISOTROPY AND INTERLAYER COUPLING IN Fe/Si/Fe TRILAYERS

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The in-plane magnetic anisotropy and interlayer coupling have been investigated in the Fe/Si/Fe trilayers grown by dc magnetron sputtering deposition on GaAs (001) substrates. The samples have been covered with thin cap layers of Si or Ge. The measurements have been performed by means of ferromagnetic resonance (FMR) as a function of the orientation of dc magnetic field in plane of the film at liquid helium and room temperatures. From these dependencies the in-plane and cubic anisotropy constants as well as interlayer coupling constants are determined. It is shown that the uniaxial in-plane anisotropy has mainly magnetoelastic origin and that easy directions are different in both layers. Moreover, the anisotropy constants in both layers have independent temperature dependencies related only to the differences in thermal expansion coefficients between Fe, Si and GaAs.

We-PA081
PREPARATION OF MULTILAYER *Co-P* FILMS

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Amorphous Co-P films attract a great attention due to the possibility of their application in storage memory devices.
In present work the multilayer Co-P films containing alternative amorphous and crystalline (phase) layers have been obtained. The content of phosphorus, depending on freguency and ratio of current pulses, can be varied from 2 till 14 at %. This fact allows to control residual magnetization, coersive force and rectangularity of hysteresis in a wide range. Besides that, fixed crystallographic texture can be formed on the crystallization front into layers with crystal phase. This texture depending on the value of supersaturation influences on total anisotropy of magnetic properties of films. Also the improvement of corrosion and wear stability of multilayer Co-P films have been observed.

We-PA082
PREPARATION OF MULTILAYER *Cu-Ni* FILMS FOR *GMR*.

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At present multilayer dielectric-ferromagnetic films are under quite intensive investigation. Both multilayer structures with solid layers and insular structures attract a great attention.
One of the methods to obtain such structures in pulsed electrolysis. Owing to using program-controlled regimes of pulsed current, which are the number of pulses with different parameters, one can easy control the structure, phase composition and thickness of layers and obtain insular structures at definite pulse group duration. In particular, bimetalic multilayer Cu-Ni films have been produced from one sulfate electrolyte by program-controlled pulsed current. The films had different structure and phase composition of forming layers. Besides the structures with alternative solid cooper layers and Ni islands have been obtained. These films are widely applicable for GMR effect. Thus, by changing regimes of program-controlled pulsed current one can vary magnito-resistive properties of electrocleposited Cu-Ni films.

We-PA083
THE PULSED CURRENT INFLUENCE ON STRUCTURE AND MAGNETIC PROPERTIES OF *Fe-Ni* ALLOYS

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Preparation of films based on the ferrum group metal alloys with fixed magnetic properties is still actual problem.
To obtain Fe-Ni alloy films the pulsed current was used. Varying of frequency and ratio of current pulses allowed us to change chemical composition of films in a wide range.
The subgrains sizes were varied from 20 to 100 nm. In contrary to films produced by direct current these had homogenous chemical composition (in depth). The deposit growth run layer by layer, and the layer thickness was controlled within 0.1–1mkm. At the same time changing in texture of forming coating occurred.
All factors mentioned above allowed to vary the magnetization of supersaturation and coercive force of obtained deposits.

We-PA084
INTERFACE ALLOYING AND INTERLAYER EXCHANGE COUPLING IN THE Fe/Cr SUPERLATTICES

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Interface alloying detected by scanning tunneling microscopy for the Cr deposited on the Fe substrate [1] as well as for the Fe deposited on the Cr substrate [2] essentially modifies all properties of Fe/Cr multilayers. Lack of the symmetry in the interface region complicates the calculations of electronic and magnetic structures and the theoretical models often presuppose ordered alloying instead of the random atom's distribution. To model realistic disordered interface alloying we developed the random procedure, which exchanges the atoms in the neighboring layers. The increase of the fraction of atoms α, which have been exchanged in every two successive layers, leads to broadening of the interface region and increase the Fe-Cr alloying. The calculations of magnetic moments for the superlattices with various degrees of alloying were performed in the framework of Periodic Anderson Model. It has been found that at the certain value of α, the magnetic ordering of superlattice changes from antiferromagnetic to ferromagnetic. Calculations of magnetic structure in non-collinear model demonstrate different role of alloyed and stepped interface roughness in the biqadratic exchange coupling formation.
The work is partially supported by RFBR No.98-02-17517 and INTAS No. 96-0531.
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We-PA085

DYNAMICAL SUSCEPTIBILITY OF A TWO-LAYER EXCHANGE COUPLED FILM IN A TILTED STRONG MAGNETIC FIELD

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The influence of the interlayer exchange coupling on magnetic resonance properties of an easy-axis/easy-plane two-layer film structure has been investigated theoretically in the case of an arbitrary orientation of a strong external magnetic field.
The analytical expressions for the resonant field dependence on the tilt angle of the magnetic field with respect to the film plane as well as the tensor of the integral high-frequency magnetic susceptibility have been obtained. The dependencies of the imaginary part of the susceptibility tensor (i.e., the intensity of microwave absorption by the film) on both the magnetic field value and its orientation as well as on the layers' thickness are analyzed.
Experimental data for epitaxial iron garnet films with a sufficiently small value of the interlayer exchange coupling parameter [1-3] are explained, and the theoretical results are in a good agreement with experiment.
The model is also applicable for the description of resonance characteristics of ion-implanted films with the strong exchange coupling between layers.

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We-PA086

FMR INVESTIGATION OF ULTRATHIN Fe/GaAs{100} FILMS

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Fe/GaAs{100} thin films and multilayers are interesting because of strong magnetism of Fe and wide using of GaAs{100} in semiconductor techniques promising a possibility to design new magnetoelectronic devices. Unfortunately {100} plane of GaAs is known as a difficult one to grow high-quality flat single-crystalline Fe film. We've investigated the dependence of magnetic properties of ultrathin (12-90 Å) Fe/GaAs{100} films grown by molecular-beam epitaxy on the growth rate and substrate's temperature using ferromagnetic resonance (FMR) at 9,8 GHz. It was found that low substrate's temperature (near the room one) and the growth rate ~3 A/min results in high-quality Fe films clearly demonstrate fourfold anisotropy and uniaxial anisotropy (note the least was found increased compared with previous data). The dependence of the FMR linewidth on the film thickness has a minimum in a region of 45 Å, where it was 20 Oe, less then all had been reported for ultrathin films on {100} substrates. The switching of easy magnetization axis direction depending on film's thickness was also investigated as a function of growth condition.
All the features of the films are considered taking into account the possible "island-like" growth of the film and the roughness of the substrate.

We-PA087

NON-LINEAR EXCITATIONS IN MAGNETIC FILMS IN THE VICINITY OF THE SINGULAR POINTS OF THE SPIN-WAVE SPECTRUM

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Magnetic films are superb model systems for investigation of magnetic solitons. Classical non-linear Schrödinger equation (NSE), as a rule, is used for a description of their evolution. In recent years it appears that it is necessary to use generalized non-linear Schrödinger equation (GNSE) for adequate description of soliton states taking into account the effects of high-order dispersion [1]. The latter is particularly actual in the vicinity of the zero-dispersion point [2].
The present report is devoted to analysis of the soliton regimes of spin-wave propagation in such magnetic media. An analysis is carried out both for exchange-dipole spin waves in ferromagnetic film magnetized along its normal direction and for bulk magnetostatic spin waves in the ferromagnetic–dielectric-metal sandwich structure. The principal properties, stability conditions and life time of “bright” and “dark” spin-wave envelope “quasi-solitons” are investigated in the vicinity of the main singular points of the spin-wave spectrum. In conclusion the possibility of experimental observation of investigated “quasi-soliton” states is discussed.

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We-PA088

DOMAIN STRUCTURE FEATURES OF PERMALLOY SANDWICHES

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Domain structure of single layer permalloy films has been enough well investigated that cannot be told about multilayer and sandwich films. In this paper we have studied effect of existence of a layer into sandwich on the domain wall structure and transition in transcritical state.
The investigation was carried out for single layer Fe19Ni81 films and sandwiches consisting of 2–10 permalloy layers separated with 2.5 nm TiN interlayers. The thickness of single layer samples was 50–500 nm and the thickness of magnetic layer of sandwich was varied from 50 to 500 nm also. All samples were prepared by r. f. sputtering and after they were annealed at 500°C. It was founded that the layers into the sandwiches did not demonstrate the attributes of transcritical state. However, the dependencies of the domain and domain wall parameters on the layer thickness had the features as compared with single layer films. Particularly, the number of 360° domain walls increased and the coercive force reduced monotonically with decreasing of the layer thickness.

We-PA089

PHYSICAL PROPERTIES AND STRUCTURE PECULIARITIES OF Fe-15.1%Nd-8.3%B FILMS

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It has been investigated the structure, phase composition, properties and temperature stability of ion-plasma sputtered thin (10-50 nm) films Fe+15.1%Nd+8.3%B (at.%) and 3-layers films – (25nm Cr)+(115nm Fe+15.1%Nd+8.3%B)+(25 nm Cr). X-ray examination and transmission electron microscopy (TME) study showed that fresh sputtered films had amorphous structure. 3-layes films had nanocrystalline structure with 10.5 nm Bragg scattering region. The analysis of short-range order in TME diffractions permit to deduce that there are rich α-Fe microregions and statistic distributed atoms of Nd and B in structure of fresh sputtered thin films. The magnetic properties of thin films are M_s=1.5 MA/m; M_r=1.2 MA/m: H_c=10.3 kA/m. These results are comparable with magnetic properties of rich α-Fe sample (M_s=1,7 MA/m). It`s ascertained that the decomposition of amorphous phase has place at 250-650°C interval. The structure of thin films is a mixture of α-Fe precipitation with cell demention a=0.2865 nm and traces of complicated oxides of Nd after heating to 700°C. The size of α-Fe precipitation is higher than 1 μm. The magnetic properties of annealing thin films are H_c=40 kA/m; M_r=1.1 MA/m; M_s=1.5MA/m. The 3-layes annealing films are characterized by rich α-Fe precipitation and traces of $Fe_{14}Nd_2B$ phase.

We-PA090

INFLUENCE OF GROWTH TEMPERATURE ON FINE STRUCTURE, MAGNETIC, AND MAGNETORESISTIVE PROPERTIES OF Fe/Cr MULTILAYERS

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It is shown that structure quality of MBE grown non-collinear Fe/Cr multilayers depends essentially on substrate temperature during growth. A series of multilayers $[Cr(10Å)/^{57}Fe(20A)]_8/Cr(70A)/Al_2O_3$ was prepared at the same growth conditions exept for substrate temperature which was varied from 20 to 480 ^{0}C. Transmission electron microscopy and X-ray diffraction show that in-plane crystallite size increases with substrate temperature increasing. The multilayer layerness keeps good up to ~400 ^{0}C. At higher temperatures, intensive diffuse intermixing eliminates the layer structure. Interface intermixing was traced with Mossbauer spectroscopy and small-angle X-ray diffraction. Clear correlation is found between layer and interface structure, magnetic and magnetoresistive properties. The magnetoresistive effect is maximum in multilayers grown at substrate temperatures about 190 ^{0}C.

The work was supported by RFBR (Grant No. 98-02-17517) and Grant-in-Aid No. 97-1080 for Research Program “Physics of Solid-State Nanostructures”.

We-PA091
PHASE DIAGRAM OF FERROMAGNET - ANTIFERROMAGNET MULTILAYERS

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The discovery of giant magnetoresistance phenomenon has attracted attention to magnetic multilayers. Recent experiments show that in the Fe/Cr and Fe/Mn multilayers Cr and, probably, Mn layers are ordered antiferromagnetically and (for thickness of tens angstroms) consist of ferromagnetic atomic planes with antiparallel spin orientation in neighbouring planes. The roughness of interfaces between layers, i.e. presence of atomic steps changing the thickness by one monoatomic layer, leads to the occurrence of frustrations in the ferromagnet – layered antiferromagnet system.
Code for calculation of order parameter distributions in ferromagnetic and antiferromagnetic layers in various states of the frustrated system has been created. We have investigated the phase diagrams "thickness-roughness" of thin ferromagnetic film on an antiferromagnetic substrate and spin-valve system "ferromagnet – antiferromagnet – ferromagnet".
The transition between multidomain phase and phase in which adjacent monodomain ferromagnetic layers have perpendicular orientation of magnetizations proceeds continuously, but there exists the first order phase transition between the last one and the phase with collinear orientation of magnetizations.

We-PA092
MAGNETIC ORDERING OF Dy IN 3d-METAL- Dy BILAYERS.

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Results of the temperature and spectral investigations of the magnetooptical effects, Auger electron spectroscopy (AES) and X-ray photoelectron spectroscopy (XES) in bilayer films 3-d transition metal (TM) -Dy, where TM is NiFe, or Fe, or Co, are presented here. Samples were prepared by thermal deposition method in ultrahigh vacuum and by rf-sputtering in argon atmosphere using separate material sources. Each cycle three samples were prepared simultaneously: Dy, bilayer Dy-TM or TM-Dy and TM. Magnetic circular dichroism (MCD) was measured in magnetic field 3.5 kOe, applied in a direction perpendicular to the plane of the samples, in the temperature interval from 300 to 80 K and spectral interval was 350-1000 nm. Kerr rotation (KR)was measured at the room temperature in longitudinal magnetic field in spectral interval 400-1000 nm. AES and XES were used to study the depth distribution of elements and their chemical state. It was shown that in the whole temperature interval investigated Dy gave the contribution in to MCD of bilayer film, corresponding to the MCD value in single-layer Dy film of the same thickness but measured below the temperature of the Dy transition into ferromagnetic state(TC=85K). The Dy layer thickness was right up to 500-700e. KR of Dy in bilayer films had the opposite sign and different spectral dependence comparing with TM. For single layer Dy films KR was not observed at room temperature. The behavior TM-Dy and Dy-TM samples are similar. The possible mechanisms of the phenomenon are discussed taking into account the AES and XES date.

We-PA093

THE COMPOSITE POWDERS NiP/CoP: THE STRUCTURE AND MAGNETIC PROPERTIES

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We have investigated structure and the magnetic behavior of composite powders produced by chemical reduction, which particle consist of core from one alloy surrounded by spherical shell from second alloy. The particle size was in the range of 0.1-3 μm. All samples of the $Ni_{100-X}P_X$/CoP series (4<x<17) have shell with cobalt contents ~ 93 at%. The NiP core having less than 5.2 at % P was crystalline with fcc-like Ni(P) structure, NiP with 5.2 to 10 at % P was partly amorphous. With more than about 10 at % P it was totally amorphous. It is found that structure of $Co_{93}P_7$ shell is determined by core structure.

The magnetic parameters determined by short-range and middle-range order (such as the saturation magnetization - M_0, the exchange stiffness constant - D, the local magnetic anisotropy field - H_a, the FMR linewidth - ΔH, the coercivity) were studied as a function of P-content. The FMR linewidth of NiP/CoP powders is proportional to the local magnetic anisotropy field. Consequently the ΔH FMR is mainly determined by the local anisotropy field.

We-PA094

PROPERTIES OF THE INTERFACES OF Fe/Si MULTILAYERED FILMS IN AN ANTIFERROMAGNETIC COUPLING

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Sublayer thickness dependence of the structure and stoichiometry of the interdiffused interfacial regions in Fe/Si multilayers (ML) exhibiting a strong antiferromagnetic (AF) coupling was investigated by the experimental and computer-simulated magneto-optical (MO) and optical spectroscopies. The strongest AF coupling between Fe sublayers was observed for $(30ÅFe/15SiÅ)_{50}$ ML structure. It was shown that neither semiconducting $FeSi_2$ nor ε-FeSi can be considered as the spacer providing the strong AF coupling. The optical properties of the spacer were extracted, which strongly support its metallic nature. A reasonable agreement between experimental and simulated equatorial-Kerr-effect spectra was obtained by using the fitted optical parameters of the spacer for the FeSi or Fe_5Si_3 stoichiometry. This fact allows us to suggest that the AF coupling in the Fe/Si ML is provided by the metallic spacer. In contrast to the Fe/Si ML with relatively thick sublayers, an amorphous structure with a short-range order close to the semiconducting ε-FeSi structure is spontaneously formed in the Fe/Si ML with sublayers thinner than 10 Å.

We-PA095

INFLUENCE OF MAGNETIC VISCOSITY MODULATION ON DAMPING OF SPIN WAVES IN MULTILAYER MAGNETIC SYSTEMS

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In this work the process of exchange spin waves (SW) propagation in multilayer magnetic with modulation of uniaxial anisotropy, exchange interaction and magnetic viscosity parameters is investigated. The consideration is carried out in continuous approach on the basis of the Landau-Lifshitz equations with the relaxation term in the Landau form. The multilayer magnetic is represented by system of the alternated homogeneous and homogeneously magnetized flat magnetic layers of two kinds. The value of the easy axis type magnetic anisotropy (an axis of easy magnetization is situated in layers plain), exchange interaction and magnetic viscosity constants has different meaning in neighbouring layers, but the saturation magnetization value and the easy axis direction are constant through total material.
Parameter of effective spatial damping (PESD) of SW is found by decomposition of the spectrum equation for multilayer magnetic under the small imaginary additives to Bloch wave number and SW wave numbers of layers, which are caused by magnetic viscosity. Is shown, that the presence of dissipation results to smearing and displacement of the forbidden zones in a spectrum of SW. Is obtained also, that changing by selection of a material parameters of layers it is possible to influence depth of penetration of SW to material. The dependence of PESD of SW on frequency of a wave and on value of a constant external magnetic field is investigated. An approach of fine-layered material is considered.

We-PA096

MAGNETIC OFF-SPECULAR NEUTRON SCATTERING IN LAMELLAR-STRUCTURED Fe/Cr SUPERLATTICES

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Interrelation of magnetic structure and nanocrystallite morphology of MBE-grown $[Fe(70A)/Cr(t)]_n/Al_2O_3$ multilayers with varying Cr interlayer thickness t has been studied with a combined approach including polarised neutron reflectometry, X-ray diffraction, transmission electron microscopy, SQUID and VSM magnetometry. It has been found that the multilayers consist of nano-scale fine crystallites arranged differently depending on Cr thickness. The samples with t=9Å displaying unusually strong in-plane magnetic anisotropy are composed of large lamellar aggregates of the crystallites with close orientation. The neighbouring lamellas are oriented in different planes, (100) and (113) planes being separated with high-angle boundaries. Neutron reflectometry revealed strong off-specular spin-flip scattering concentrated at half order position of nuclear Bragg-peaks. The neutron scattering picture is associated with in-plane domain structure. Estimated in-plane length scale of magnetic inhomogeneity does not exceed the typical size of lamellar structure.
The work was supported by Grants of RFBR and MS of RF.

We-PA097
DOMAIN WALLS IN MAGNETIC MULTILAYERS.

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Static and dynamic properties of domain walls in magnetic multilayers are theoretically studied. Heisenberg and biquadratic exchange interaction between magnetic layers are taking into account. The case of wall perpendicular to the magnetic layers plane are considered. It is found eight exact static solutions corresponding to the various types of domain walls in multilayers. Some of them have no analogue in usual magnet. The nonlinear equations of the dynamics of the magnetization for the antiferromagnetic exchange interaction between magnetic layers are derived. The domain wall dynamics is studied in two different approximations: a strong exchange approximation and a strong demagnetization energy.

We-PA098
INVESTIGATION OF APPROACH TO MAGNETIC SATURATION OF THIN Co(P) FILMS AND Co(P)/Pd MULTILAYERS

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We report results of experimental investigation of approach to magnetic saturation law in Co(P) films and Co(P)/Pd multilayers.
It is assumed that individual Co layers (amorphous or nanocrystalline) are developed in the form of clusters or nanocrystalline grains. For planar allocation of Co clusters within layer, thin films and multilayers can be considered as a two-dimensional magnetic structure. This would be result in some features on magnetization curves of such materials. Magnetization curve, in the applied fields range there is no domain structure approximately defined as $M_z \approx Ms(1-d_m)$, there d_m is the dispersion of stochastic magnetic structure. Theoretical expression for d_m obtained in [1] includes in two asymptotic dependencies of $d_m(H)$: $d_m \sim H^{-(4-d)/2}$ for $H \ll 2A/M \cdot r_c^2$ and $d_m \sim H^{-2}$ for $H \gg 2A/M \cdot r_c^2$, there A –exchange, M –magnetization, $2 \cdot r_c$ –size of cluster or nanocrystalline grain, d -dimensionality of the grains packing.
All films and multylayers is characterized by high field asymptotic behavior $d_m \sim H^{-2}$ independently on structure and thickness of film or individual layers.
The features of $d_m(H)$ in thick films is low field asymptotic behavior - the power dependence $d_m \sim H^{-1/2}$. This points out on 3-dimmension packing of grains (with the size $\sim 2r_c$) in such films. The $d_m(H)$ dependence both for the thin films of alloy Co(P) and for the Co(P)/Pd multilayeres show $d_m \sim H^{-1}$ behavior in the some range of applied fields that allow to determine dimentionality of grains packing as d=2.

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We-PA099

STUDY OF INTERFACES IN Fe/V MULTILAYERS: Fe ON V AND V ON Fe.

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The different interface Fe layers in Fe/V multilayers was examined by Mössbauer spectroscopy using ^{57}Fe as a probe atom. The samples was prepared in the same way, but two mono layers of ^{57}Fe probe was placed in the first case on top of each V sublayer and in the second case on top of each Fe sublayer. Previous studies [1] were not focussed on detecting any difference between these two types of interfaces, but according to results from other systems, a difference could be suspected because of different interface energies for different elements [2]. The interface structure was analyzed by X-ray diffraction and Conversion Electron Mössbauer Spectroscopy (CEMS) at room temperature.
The hyperfine field distribution for the two interfaces prove to be essentially different. The results show that the Fe interface is smoother than the V one. A markedly larger contribution from bulk like hyperfine field was observed for the sample where ^{57}Fe was placed on top of Fe.

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We-PA100

EFFECT OF NON-MAGNETIC INTERLAYER ON MAGNETIC ORDERING IN Gd/X/Co/X MULTILAYERED FILMS

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We have studied the peculiarities of magnetic ordering in $\{Gd/X/Co/X\}_{20}$ multilayered films having non-magnetic interlayers with different conduction (X=Cu,Si). Films were prepared by rf sputtering. The thickness of Gd and Co layers was 75 Å and 30 Å, respectively. The thickness of non-magnetic interlayers was varied from 0 to 10 Å.
The temperature dependences of spontaneous magnetization show that there is a negative exchange coupling between the Gd and Co layers leading to a magnetic compensation state at a certain temperature (T_{comp}). Adding the non-magnetic interlayers results in a decrease of compensation temperature and appearance the dependence of T_{comp} on external magnetic field H. The theoretical interpretation of the $T_{comp}(L,H)$ dependences was done on the suggestion about inhomogeneous interlayer interaction [1] and paraprocess in Gd layers. The influence of the kind of non-magnetic interlayer on T_{comp} is discussed.

[1] V.O. Vas'kovskiy, D. Garcia, A.V. Svalov, A. Hernando, M. Vazquez, G.V. Kurlyandskaya, A.V. Gorbunov // Phys. Met. Metall. 86 (1998) p. 140.

We-PA101
MAGNETIC STUDIES OF NANOSCALE LASER PATTERNED STRUCTURES

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Nanoscale magnetic entities are of great interest from a fundamental viewpoint and for applications especially in information storage technology. As the dimensions of the magnetic entities became smaller many of its properties can be significantly enhanced or even totally different. We have recently developed a technique using atomic force microscope (AFM) to investigate the magnetostrictive response of dots prepared by e-beam lithography technique[1]. It was found the magnetostrictive value is enhanced by orders of magnitude as compared of to bulk Co films.
In this presentation we will discuss our investigations on FeCr and Co-based magnetic nano-entities, prepared by laser four-beam thin film patterning.
Finally, we will compare the response of these patterns with the observed properties for patterned magnetic dots fabricated by electron-beam lithography.

[1] J.Wittborn, K.V. Rao, J. Nogués, I.K. Schuller.// to appear in Appl. Phys. Letters (May 15 issue 2000)

We-PA102
VERY FINE MAGNETIC PARTICLES OF Cr_2O_3 IN THE LAYERED COMPOUND α-ZIRCONIUM PHOSPHATE: INFLUENCE OF Li^+ AND K^+ DOPING.

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Very fine particles of chromium oxide are formed when this inorganic oligomer is inserted in the layered compound α-zirconium phosphate, giving rise to a mesoporous solid with an important contribution of micropores. Relaxational behaviour has been found in $\chi_{a.c.}$ measurements for the undoped and doped with Li^+ and K^+ solids, with slight differences among them. Quite similar behaviour has been found in mixed Cr/Fe oxide pillared materials [1,2]. Differences between both type of compounds are pointed out and the influence of Li^+ and K^+ cations on the particle size and particle interactions are discussed.

[1] M. Gabás, J.R. Ramos-Barrado, F.J. Pérez-Reina, E. Rodríguez-Castellón and A. Jiménez-López, J. Magn. Magn. Mater. 196-197 (1999), p. 218.
[2] M. Gabás, J.R. Ramos-Barrado, A. Jiménez-López, E. Rodríguez-Castellón and J. Mérida-Robles, sent to Journal of Solid State Chemistry.

We-PA103

EFFECTS OF SHOCK WAVE LOADING AND HEAT TREATMENT ON STRUCTURE AND MAGNETIC PROPERTIES OF FINE COMPOSITE POWDER CoP/Cu.

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We have investigated the structure and magnetic behavior of composite powders Co(P)/Cu produced by chemical reduction, which particle consist of core from Co(P) alloy surrounded by spherical shell from Cu. The particles size was in the range of 0.1-3 μm. In the $Co_{100-X}P_X$/Cu system with 4< x <18 X-ray investigations revealed a change of the core structure from hcp-like Co(P) solid solution to an amorphous Co-P alloy with increasing P-content. The Cu shell was crystalline with fcc structure. The magnetic parameters determined by short-range and middle-range order (such as the saturation magnetization - M_0, the exchange stiffness constant - D, the local magnetic anisotropy field - H_a, the FMR linewidth - ΔH, the coercivity H_c) were studied as a function of P-content. The influences of heat treatment and shock wave loading (SWL) on the structure and magnetic parameters of Co(P)/Cu powders have been investigated. It is found that the heat treatment with $T>250^{O}C$ for all contents Cu and SWL of powders having more than 40at% Cu facilitate the phase separation of the alloy. The SWL leads to decreasing of ΔH FMR and value of coercivity for Co(P)/Cu powders. With an increase in annealing temperature the coercive field decreases while the magnetization increases, reflecting particle coarsening and the relative amount of free cobalt in the mixture.

We-PA104

THICKNESS DEPENDENCE OF EXCHANGE BIAS WITH A METAL SPACER

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Exchange bias between antiferromagnetic (AF)/ferromagnetic (FM) layers attracts a lot of attentions for the intensive studies of spin-valve multilayers. It has been shown that both the strength and the sign of the exchange bias field can be tailored under the appropriate cooling-field procedure. Recently a metal spacer is inserted between the AF and FM and the results was shown that the strength of exchange bias can also adjusted through the variation of the thickness of the metal spacer. However, exchange bias mechanism through the metal spacer remains unclear.

Here we theoretically analyze the role of the metal spacer. Considering the magnetic ions within AF and FM layers are coupling through the conduction electrons, we use RKKY interaction to study the influence of the layer thickness of either metal and magnetic layers. We found that oscillatory period of the exchange bias varies with thickness of FM layer. The role of the AF layer thickness is also studied and the results show that the strength of the exchange bias is enhanced with the increasing AF layer thickness. Comparison between the theory and experimental results are reasonable good.

We-PA105

SPIN - WAVE RESONANCE IN Co/Pd, Co/Ni MULTILAYER FILMS.

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The energy gap appearing in the spin-wave spectrum as a result of Bragg scattering by the modulation period $q=2\pi/(d_1+d_2)$ of a one-dimensional superlattice is observed by the method of spin-wave resonance in Co/Pd and Co/Ni multilayer films. It is shown that this gap is asymmetric. The "positive" deviation is from two to three times greater than the "negative" deviation. Also the effect of magnitude modification of effective exchange stiffness for spin - wave with $k=q/3$ and $k=q/5$ has been found.

We-PA106

ALTERNATING MAGNETIZATION OF SOFT FERROMAGNETIC SANDWICHES

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The alternating magnetization of three-layer sandwich consisting of soft ferromagnetic outer layers and spacer having a high conductivity is studied theoretically. The sandwich is placed in the DC magnetic field, and the AC current is assumed to flow through the highly conductive spacer only. Both the collinear and the transverse directions of the DC magnetic field with the respect to the AC current direction are studied. The magnetization reversal process is described in terms of the quasi-stationary approach. The ferromagnetic film is assumed to have a single-domain structure. The finite size of the sandwich takes into account through the demagnetizing factors. The validity of this approach is discussed. It is assumed that easy magnetization axes have different directions in each magnetic layer. The voltage arising in the pick-up coil wounded around the sandwich is calculated. The peculiarities of the pick-up coil voltage frequency spectrum are investigated. It is shown that the form of the frequency spectrum is very sensitive to the value and direction of the applied DC magnetic field. A comparison of the results obtained with measurements is discussed. The studied effects are very promising for the developing of miniature magnetic sensors.

The work is supported by ISTC under Grant 766-98.

Poster Session **Wednesday, June 7, 2000**
Section A (Topics 01, 14, 15)

We-PA107

THE INFLUENCE OF INTERFACE AND SURFACE EFFECTS ON THE MAGNETIC PROPERTIES OF THIN IRON FILMS

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The incorporation of magnetic layers in semiconductor heterostructures is an increasingly active area of study. There is great interest in the catalytic, electronic and magnetic properties of transition metal overlayers on semiconductor substrates in thin film form.

Since the metal-semiconductor interface plays an important role in thin film heterostructures the initial stages of overlayer growth determine the morphology and crystalline structure of subsequent growth. Properties of thin films often differ significantly from those of the bulk due to surface and interface effects dominating the overall behavior of these films. Iron films show a broad range of magnetic properties depending on film thickness and deposition conditions.

We investigate the influence of the initial substrate surface reconstruction on the magnetic behavior of iron films both on GaAs substrates as well as on ZnSe epilayers. Surface reconstructions lead to magnetic anisotropies dominated by an in-plane uniaxial component.

We study the growth of ferromagnetic iron to determine the mode of film growth, formation of the interface and magnetic properties of the films. Films are characterized by various measurements - surface reconstructions are determined by reflection high energy electron diffraction (RHEED), magnetic properties by superconducting quantum interference device (SQUID) and the mode of film growth by atomic force microscopy (AFM).

We-PA108

TUNNELING MAGNETORESISTANT EFFECT OF Co-Sm-O GRANULAR FILMS DEPOSITED ON FeNi FILMS WITH NANO-FURROW STRUCTURES FORMED BY OBLIQUE SPUTTERING

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Recently, Kobayashi et al. showed that the use of granular-in-gap (GIG) structure is very effective for softening the tunneling magnetoresistance (TMR) effect [1]. However, the formation of GIG structure necessitates the micro-fabrication technique, which is unfavorable for practical applications. In this paper, we demonstrate that the use of obliquely sputtered FeNi film as an underlayer of the granular film is very effective to obtain the similar effect as the GIG structure. Because the FeNi film thus obtained had self-assembled nano-furrow structure, in which the stray field acting between the neighboring FeNi furrow contributes the TMR softening of granular films. For instance, as shown in Fig.1, the granular film with $Co_{51}(Sm_2O_3)_{49}$ composition exhibits the TMR of about 6.6% at 12kOe, while the same granular film deposited onto the obliquely sputtered FeNi film shows the resistance change of about 3.0% at about 25Oe.

[1] N. Kobayashi et al., J. Magn. Magn. Mat., 188 (1998) pp30-34.

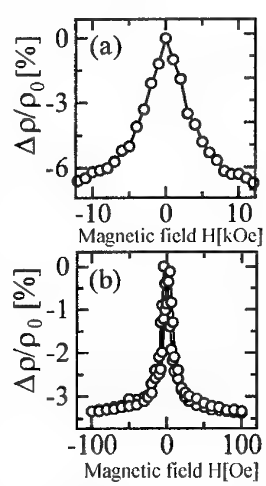

Fig.1 $\Delta\rho/\rho_0$ vs H for a film.
(a) CoSmO single layer film,
(b) NiFe/CoSmO Composite film.

We-PA109

THERMAL ANNEALING INFLUENCE ON THE RESISTANCE AND MAGNETORESISTANCE OF AMORPHOUS CoFeB-SiO$_n$ COMPOSITES

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Influence of a thermal annealing on the electrical resistance and magnetoresistance of amorphous granular $(Co_{41}Fe_{39}B_{20})(SiO_n)$ composites was studied.

The $(Co_{41}Fe_{39}B_{20})_x(SiO_n)_{100-x}$ granular nano-composites have been obtained as a thin films (~1 μm) by ion-beam sputtering of a mosaic target. The structure investigation of the films were made by transmission electron microscopy. The CoFeB granule sizes of the as-deposited samples are 2-7 nanometers depending on the composition, at the same time the composites structure itself is amorphous. All granular composites $(Co_{41}Fe_{39}B_{20})(SiO_n)$ exhibit a giant magnetoresistance (GMR) at room temperature with a maximum value of 3.5 % at 1.2 T.

Isothermal annealing of the composites in vacuum at 300 ^{0}C leads to increasing of the GMR and rising of the electrical resistance of the samples. The GMR change is observed to be 10÷20 % from the initial value but the samples resistance becomes approximately one order larger.

Crystallization of the amorphous composites $(Co_{41}Fe_{39}B_{20})_x(SiO_n)_{100-x}$ has been observed in all studied samples in the same temperature region (425-525 ^{0}C). The drastically change of the composites structure occurs during the crystallization and it changes the transport properties: samples resistivity sharply drops down (the reduction is one of two order depending on the composition). At the same time magnetoresistance does not observed in the samples after annealing at 600 ^{0}C.

MAGNETORESISTIVE AND MAGNETIC PROPERTIES OF THE GRANULAR CoNbTa-SiO$_n$ COMPOSITES

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Electrical resistance, magnetoresistance as well as magnetic properties of a new soft-magnetic metal/insulator granular nano-composites (ferromagnetic granules are inside the dielectric matrix) have been studied in the present work.

The $(Co_{86}Nb_{12}Ta_2)_x(SiO_n)_{100-x}$ composites ($1 \le n \le 2$, $23 \le x \le 100$, at %) were obtained as a films by ion-beam sputtering of the mosaic target in a low pressure Ar atmosphere. The thin films (~600÷900 Å) were prepared for transmission electron microscopy (TEM) study and a thick films (4÷5 μm) were prepared for investigation of the samples physical properties.

According to the TEM investigation the composites are a granular materials (except for the pure $Co_{86}Nb_{12}Ta_2$) and the granule sizes are several nanometers depending on the metal/insulator ratio. At the same time the granules and SiO_2 matrix have amorphous structure. The composites electrical resistivity monotonously increases with metal fraction decreasing (from $3.4 \cdot 10^{-4}$ Ohm·cm to $5.7 \cdot 10^3$Ohm·cm, while the $(Co_{86}Nb_{12}Ta_2)$ concentration decreases from 100 to 23 at %). The composites magnetoresistance (MR) nonlinear depends on the metal phase concentration reaching the maximum value of the MR equal to 0.52 % in $(Co_{86}Nb_{12}Ta_2)_{55}(SiO_n)_{45}$ at 1.2 T external magnetic field. Magnetization processes of the composites as well as its thermomagnetic behavior in a temperature range 77 - 300 K have been also studied. The interrelationship between the MR and magnetic properties as well as relatively low values of the MR in these materials are discussed.

We-PA111
MAGNETIC RELAXATION IN CHAIN-OF-SPHERES PARTICLES

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The chain of spheres was the first model to describe the incoherent magnetization reversal in elongated magnetic particles. In recent years the model has been shown to govern the magnetic reversal behavior of many magnetic systems, e.g. chains composed of nanosize ferromagnetic spheres [1]. In such small particles, thermally activated relaxation of the magnetization is very important. However, the effect of thermal agitation for chain-of-spheres model is not considered till now. In order to gain further insight into the magnetization process of such particles, it is deserved to study the thermal relaxation in the chain-of-spheres particles. Here the spheres are assumed to be uniformly magnetized. Magnetostatic interaction among theses spheres and exchange coupling between adjacent spheres are allowed. The effect of uniaxial magnetocrystalline anisotropy along the chain axis is also taken into account. We have studied the influences of temperature and field sweeping rate on the angular dependence of coercivity for such particles. Effective activation volume for different aspect ratio of the elongated particle is also calculated. It was found that activation volume will be smaller than that due to coherent rotation mode and be saturated at a large aspect ratio.

[1] L. Zhang and A. Manthiram, Phys. Rev. B 54, (1996), p.3462.

We-PA112
ON A NEW METHOD FOR PREPARING FERRITE POWDERS

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In order to obtain the fine ferrite powders with submicronic size crystallites, we describe a new method, as improved variant of the method of coprecipitation. According to this method, the substances in the reaction are metal nitrates and ammonium hydroxide, the coprecipitation takes place into a colloidal medium and the reaction of forming ferrite is a quick combustion of the sol and gel mixture.
Due to the use of metallic nitrates and polivinylic alcohol, after the combustion, it results a homogeneous product with a precise determined composition and submicronic structure that does not need washing operations.
By thermal treatments one achieves the growth of crystallites up to the needed size. The resulting product has an uniform structure and controllable magnetic properties.
We used this method for preparing barium hexaferrite powder. By eliminating decanting, ablution and filtering, the method insures a precise composition of the ferrite. By avoiding the flocculation of the precipitate, a better homogeneity was obtained.
The method described, which we call "self-combustion method", is rather simple, quick and inexpensive, uses easy to get materials and is low energy consuming.

We-PA113

FMR IN NANOPARTICLES WITH A SURFACE ANISOTROPY

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Ferromagnetic resonance (FMR) in a spherical particle with surface anisotropy is considered in the framework of the micromagnetic theory. The first case is the combination of the Aharoni (surface uniaxial) anisotropy and the co-aligned bulk uniaxial anisotropy. We study the lowest eigenmode that replaces the uniform precession and thus is "visible" by a conventional FMR technique. Resonance frequencies and relaxation rates are found for a strong external field that is either parallel to the easy axis or perpendicular to it. Spatial modulation of the precession and the shifts of the resonance field are analyzed. Sign and magnitude of the shift depend on the angle between the particle axis and the external field. Theoretical results agree well with the FMR data on suspensions of size-sorted maghemite nanoparticles [1].
Another FMR problem is solved for a particle with a rotatable exchange surface anisotropy, whose direction follows the external field. As any surface pinning, it causes non-uniform magnetic oscillations, but is unique by producing an angular-independent shift of the resonance field. Some time ago such an effect has been observed with FMR on frozen magnetic fluids, but at that time remained enigmatic. Now it has found its explanation.
This work was partially supported by INTAS under grant 97–31311.
[1] Shilov V.P. et al.// J. Appl. Phys. 85 (1999) 6642; Phys Rev. B 60 (1999) 11902.

We-PA114

LOW-FIELD MICROWAVE ABSORPTION AND MAGNETIC PROPERTIES OF THE SMALL FERROMAGNETIC PARTICLES

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Microwave and static magnetic properties of the small ferromagnetic (iron, nickel, steel etc.) particles, diluted by high-pure diamagnetic powders are investigated in the 77÷1000 K temperature range. For dilution of small ferromagnetic particles (average size d_{av}=5÷30 μm) were used crystalline Ga_2O_3, GeO_2, Al_2O_3 powders and (CaO-Ga_2O_3-GeO_2) powdered glasses. Firstly an intense low-field microwave absorption (LFMA) signal from diluted particles have been observed using the X-band (ν≅9.4 GHz) electron paramagnetic resonance technique. The LFMA signal was characterised by broad absorption line ($\Delta H_{pp} \cong 3000$ G) of Lorentz shape centred near the zero value of magnetic field. Linewidth and intensity of the observed signals are independent of dilute compounds. Intensity of the LFMA signal monotonously decreases with increasing of temperature and strongly increases with decreasing of average particles size.
Static magnetic susceptibilities of diluted small ferromagnetic particles are characterised by high paramagnetic (or superparamagnetic) value. The susceptibility is a linear function of inverse magnetic field and strongly increases with decreasing of particle size. Susceptibility of diluted ferromagnetic particles decreases with temperature increasing in the 400÷1000 K range. The obtained results show, that small ferromagnetic particles in diamagnetic media form a superparamagnetic (or spin glass) state with no net magnetic moment at zero magnetic field. The observed LFMA signal reflects the magnetisation process of diluted ferromagnetic particles.

We-PA115

POLARIZABILITY TENSORS OF SMALL BIANISOTROPIC ELLIPSOID EMBEDDED IN ENVIRONMENT WITH MAGNETIC ANISOTROPY

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Low frequency diffraction of a plane wave by a bianisotropic ellipsoid immersed into an homogeneous anisotropic magnetodielectric medium is investigated in this report. The integrodifferential equations governing the interior electromagnetic fields of the ellipsoid are solved analitically via the method of Newton's potentials of an ellipsoid. The permittivity and polarizability dyads of the ellipsoid as well as the tensors of crosspolarizability may be quite arbitrary. The principal axes of the ellipsoid may all have different orientations. The obtained results for the polarizability tensors of the ellipsoid are presented in lucid, concise and highly symmetric form using six-vector notations. Outcome of the undertaken investigation seems useful for predicting effective properties of particle-laden media.

We-PA116

STM STUDY OF MAGNETIC CERMET GRANULAR THIN FILMS.

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STM observations of (CoFe)-(HfO_2) and (CoFe)-(Al_2O_3) thin films were carried out at room temperature in vacuum $5 \cdot 10^{-4}$ Pa using a W tip. Specimens have been prepared by electron-beam co-evaporation of CoFe and dielectrics HfO_2, Al_2O_3 in vacuum 10^{-6} Pa and revealed GMR effect. STM topographic images demonstrate nanoscale bright round-shaped spots on the dark background, which we consider to be metal granules of CoFe on the nonmetal matrix of HfO_2 and Al_2O_3. The previous scanning tunneling spectroscopy studying of the Co_{36} $Al_{22}O_{42}$ thin film confirms this interpretation [1]. The diameters of metal granules is very close to that obtained from the TEM micrographs.

[1]J.Chiba, S.Mitani, K.Takanashi and H.Fujimori // J.Magn. Soc. Japan, 23, (1999), p.82 .

We-PA117

MAGNETOHYSTERESIS PHENOMENA IN GRANULAR FILM

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The influence of a perpendicular magnetic field up-to 40 Oe on surface topography of granular $Co_{70}Ag_{30}$ film was studied by vacuum scanning tunnel microscope (VSTM). The transformation of the surface topography in the magnetic field was observed.

Fig.1 and Fig.2 show scanning electron micrographs of the same fragment of granular film surface in a case of absence and in magnetic field 40 Oe accordingly. The analysis of the obtained results shows that a magnetic field produces qualitative changes in the tunnel characteristic of surface elements. It is obvious that magnitude of a tunnel current depends on an external magnetic field and change of surface electronic states on account of magnetic granule polarization.

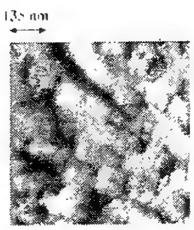

Fig. 1.

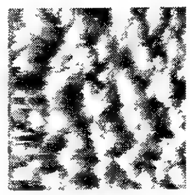

Fig. 2.

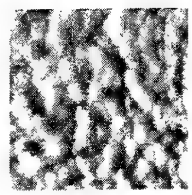

Fig. 3.

The image depicted on Fig.3 characterizes tunnel properties of the same surface after switching-off the magnetic field. Presence of magnetic hysteresis effect in the film clearly indicates on an essential role of a magnetic subsystem polarization in changing of surface electronic states.

We-PA118

OPTICAL AND MAGNETO-OPTICAL PROPERTIES OF Co-Ag GRANULAR FILMS.

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[2]Institute for information recording NAS of Ukraine, 2 Shpack str., 03113, Kyiv, Ukraine
[3]Department of Materials, University of Oxford, Oxford, Parks Road, OX1 3PH, UK

Optical constants n, k, polar Kerr rotation spectra θ_k, the polar and longitudinal magneto-optical hysteresis loops of Co_xAg_{1-x} granular films, with x varying from 0.08 to 0.7 vol.% were measured in the 350-1100 nm wavelength range.

The θ_k spectrum exhibit large peak around 450 nm. While Co volume fraction decreases from 0.6 to 0.08 the peak maximum of θ_k increases from about 0.25 to 0.37 deg in the spectral region 400-500 nm. Thermal annealing leads to increasing the θ_k with simultaneous shifting of peaks in spectra towards lower wavelength (blue shift). The absorption spectra of the films also possess the feature at wavelength $\lambda \approx 400$ nm. We believed that the anomaly in the absorption spectra and the large enhancement of the polar Kerr rotation observed in the films arises from the surface plasmon resonance of the spatially confined electrons in the small Co granules. The existent surface plasmom causes the change of dielectric function, and leads to the appearing large optical and magneto-optical anomalies in the vicinity of the surface plasmon resonance frequency. The large Kerr rotation peak in the violet spectral region would make Co-Ag granular films a very promising materials for high-density magneto-optical recording.

We-PA119

STRUCTURE AND MAGNETORESISTANCE OF GRANULAR FERROMAGNETS $(Co_{50}Fe_{50})_x$-Ag_{1-x} AND $(Co_{50}Fe_{50})_x$-$(Al_2O_3)_{1-x}$

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The discovery of giant magnetoresistance (GMR) effect in granular ferromagnets caused intensive study of these materials, as they are promising for magnetic sensors and magneto optic applications. The GMR effect is observed in various magnetic metal - nonmagnetic metal/insulator granular systems. The nature of electron transport is different in case of metal and insulator matrix. To investigate the influence of non-magnetic matrix on structure, GMR and magnetic properties series of granular $(Co_{50}Fe_{50})_x$-Ag_{1-x} and $(Co_{50}Fe_{50})_x$-$(Al_2O_3)_{1-x}$ (where x is vol.%) films with thickness 400 nm were deposited on glass substrates using electron beam evaporation techniques in vacuum 10^{-4}Pa.
The percolation threshold for $(Co_{50}Fe_{50})_x$-$(Al_2O_3)_{1-x}$ films was determined from resistance measurements as x=0.175. The highest isotropic GMR effect was observed for the both systems in narrow concentration range $0.16<x<0.18$. These compositions correspond the vicinity of percolation threshold. The highest GMR values are 7.2% and 9% in the magnetic field 8.2 kOe for the films with Al_2O_3 and Ag matrix respectively. For higher x the infinitive percolation cluster of magnetic metal causes rice of anisotropic magnetoresistive effect and reduction of GMR effect. The GMR effect and magnetic properties of the investigated systems is shown to be essentially independent on the nature of nonmagnetic matrix.

We-PA120

FMR IN $(Co_{50}Fe_{50})_x$-$(Al_2O_3)_{1-x}$ FILMS WITH INDUCED IN-PLANE ANISOTROPY

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The superparamagnetic (SP) particles are known to be quite important for magnetoresistance (MR) in granular films but their physics is not completely clear. FMR study of films below saturation provides a unique information on SP behavior. Recently we showed that a reduction of GMR saturation field in CIP geometry in Co-Cu granular films is possible while inducing the in-plane anisotropy. The same effect was also expected to be obtained in cermet films, that would be attractive as the simplest way of increasing %MR/Oe in granular material.
A series of $(Co_{50}Fe_{50})_x$–$(Al_2O_3)_{1-x}$ films (7 vol% $< x <$ 52 vol%) fabricated by electron-beam co-evaporation has been investigated using X-band FMR and MR techniques. The angular and concentration dependencies of the resonance field, H_r, and the concentration dependence of the parallel resonance linewidth, ΔH, at both room and liquid nitrogen temperatures have been obtained. Both the evident drop of FMR effective field H_{eff} at room temperature and ΔH narrowing below the concentration f_m of *magnetic percolation,* are due to the effect of SP fraction in accordance with the theoretical model [1]. Starting from the *structural percolation* point f_s and above it, the strong in-plane anisotropy (due to oblique deposition) was detected. Unfortunately, the expected TMR behavior was suppressed here by strong enough AMR effect reaching maximum for current and external field parallel to the easy axis.

[1] G.N.Kakazei et al. J.Appl.Phys., **85** (1999) 5654.

We-PA121

FMR IN $CoFe/Al_2O_3$ MULTILAYERS UNDER PERCOLATION IN CoFe LAYERS

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We studied $Co_{80}Fe_{20}/Al_2O_3$ system of discontinuous metal-insulator multilayers (DMIM), which combines the properties of both multilayers (ML) and granular films (GF). With growing thickness of ferromagnetic sublayer, the percolation process takes place in DMIM's which can differ from that in ordinary GF's: we suppose that here the ferromagnetic fraction is developed through increase of the average particle size rather than their number as in GF's. To evaluate the relation between the ferromagnetic and superparamagnetic fractions in this course, we performed a FMR study on the series of $Co_{80}Fe_{20}/Al_2O_3$ ML's where ferromagnetic sublayer thickness, t, was varied ($8 \leq t \leq 25$ Å) across the transition from discontinuous to continuous state, at fixed spacer thickness (t_s = 30Å). The samples have been fabricated using ion-beam deposition.
X-band FMR spectra in the samples have been recorded at liquid nitrogen and room temperatures using standard EPR spectrometer. The t-dependencies of the effective anisotropy field $H_{eff}(t)$, and of the parallel resonance linewidth, $\Delta H(t)$ were found quite different at two temperatures. They are interpreted within the above mentioned picture of DMIM structural evolution, taking into account (temperature dependent) competition between magnetodipolar and Néel contributions to granule anisotropy. Three characteristic regions observed in the curve $H_{eff}(t)$ and a pronounced peak (at room temperature) in $\Delta H(t)$ correlate well with the previously obtained magnetoresistance data in these samples.

We-PA122

GALVANOMAGNETIC EFFECTS IN $Ni_{81}Fe_{19}$ THIN FILMS UNDER IN-PLANE AND OUT-OF-PLANE MAGNETIC FIELD

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$Ni_{81}Fe_{19}$ films with 50 nm thickness have been prepared by electron beam evaporation, and lithographic masks were used to obtain (5 contact) samples for simultaneous measurement of longitudinal and transverse voltage relative to current $\boldsymbol{I}$ (x axis). The magnetic field $\boldsymbol{H}$ orientation was defined by the polar angle θ (with the film normal) and azimuthal angle φ (in the xy plane). With $\boldsymbol{H}$ in plane, we measured the transverse voltage V_t across opposite contacts (y direction) as a function of φ. We obtained the planar Hall effect (PHE) contribution ~$\sin 2\varphi$ superimposed on a φ-independent term attributed to a small misalignment of the voltage contacts line (not strictly $\perp$ to $\boldsymbol{I}$). The latter effect leads to a considerable enhancement of the sensitivity $S = (\mu_0 I)^{-1}\partial V_t/\partial H$ at low fields, almost doubling the PHE effect when $\varphi \approx \pi/4$, with $S \approx 300$ V/T·A.
With $\boldsymbol{H}$ out of plane, we have to separate from V_t the PHE and extraordinary Hall effect (EHE) contributions using their different symmetry with respect to inversion of H (even/odd for PHE/EHE). With $\boldsymbol{H}$ direction close to normal, besides the usual sharp PHE peak at low fields, we also observed a broad bell-shaped contribution to the even V_t part, extending up to high fields; this extra term changes sign when $\varphi \to \varphi + \pi$.
The simultaneous measurements of the longitudinal voltage $V_l(H)$ reveal a similar superposition of sharp and broad features in the even part; in this case the broad term does not change sign. We discuss these phenomena in terms of anisotropic electron scattering by magnetic moments with out-of-plane alignment.

We-PA123

INFLUENCE OF HIGH HYDROSTATIC PRESSURE ON MAGNETIC PROPERTIES OF NANO-CRYSTALLIZED Co-BASED METALLIC GLASS

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Rapidly quenched $Co_{66}Nb_9Cu_1Si_{12}B_{12}$ metallic glass exhibits Curie temperature around 100K in its amorphous state. The ribbon was annealed at 863K for 1h to create nanocrystalline structure comprising Co-based solid solution crystallites of average size around 10 nm (TEM and X-ray diffraction) embedded in the amorphous matrix. Coercivity and magnetization of the sample were measured in a SQUID magnetometer as a function of temperature (10-300K) in fields up to 3 T under the pressure up to 6 kbar using a miniature high pressure cell. The magnetization measurements show that the pressure shifts Curie point of the amorphous matrix by –0.57 K/kbar . For higher temperatures at which the matrix is paramagnetic, the sample essentially behaves like an assembly of single-domain superparamagnetic particles. To examine the effect of pressure on the interactions between particles, the isothermal remanence and the dc-demagnetization curves were measured without and under the pressure for several characteristic temperatures of the sample. An analysis of these curves, based on the Henkel plot, shows that the largest deviations from the Stoner-Wohlfarth model of non-interacting particles occur at temperatures close to Curie point of the matrix. The effect of pressure on these deviations is also most pronounced at these temperatures.The analysis of the results obtained at ambient conditions and under pressure allows us to suppose that at these temperatures ferromagnetic particles polarize the magnetically weaker matrix and the sample behaves like a system of interacting small unstable regions with magnetic random orientations.

We-PA124

NOISE-INDUCED RESONANCES IN SUPERPARAMAGNETIC PARTICLES

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Studies on stochastic resonance have revealed a variety of remarkable properties in noisy dynamic systems. In particular, the *noise-induced resonances* (NIR) have been found. NIR effect in a system driven by a strong ac external field means the occurrence of "dips" on the amplitudes of higher harmonics plotted as functions of the noise power or field strength. Another effect, caused by an imposing a bias constant field, is the appearance of odd/even harmonics. Both phenomena are now under investigation in view of their importance for detection/enhancement of weak signals. On the basis of the Fokker-Planck equation describing magnetization motion in an individual superparamagnetic particle, we present a unified description of the above nonlinear effects. Exact (in terms of matrix continued fractions) and numerically-exact solutions are analyzed from the viewpoint of under what conditions the non-monotonic behavior of the higher harmonics of the nonlinear response does arise. Possibilities of observation of these nonlinear effects in magnetic fluids are discussed. The support of the work by INTAS under grant 96-0663 is gratefully acknowledged.

We-PA125
SPIN-WAVE SPECTRA OF NON-ELLIPSOIDAL MAGNETIC DOTS

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The dots are submicron-sized magnetic particles. The magnetic properties of the dot arrays are intensively studying because their possible applications as magnetic recording media are promising. Spin-wave spectrum of the dots is necessary for description of dot magnetization switching. High-frequency dynamic properties of such patterned magnetic films have not been investigated theoretically.
In this paper we calculate discrete spin-wave spectra of in-plane magnetized non-ellipsoidal (cylindrical and rectangular) magnetic dots. The dots are assumed to be single domain particles. We take into account both intradot dipole-dipole and exchange interactions. We consider the case when the in-plane dot size is much larger than the dot height (film thickness), and assume the uniform distribution of the variable magnetization along the dot height. The general surface spin-pinning conditions are considered. The spectrum of spin-wave excitations with in-plane wave vectors is found from the solution of the Landau-Lifshitz equation and the magnetostatic Maxwell equations by means of the tensorial Green functions method. We neglect interdot magnetostatic coupling and get spin-wave dispersion equation that in the diagonal approximation is reduced to a simple analytical form similar to one for an infinite film. The cases when non-diagonal approach is necessary are discussed. The lowest mode is described by the Kittel's equation with averaged demagnetizing factors. The quantization effect of the spin-wave frequencies appears due to the finite dot size. We calculate spectrum of the discrete spin-wave modes in a practically important case of square array of permalloy (FeNi) cylindrical dots.

We-PA-126
MAGNETOSTATIC INTERDOT COUPLING IN SINGLE DOMAIN DOT ARRAYS

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The magnetostatic interaction is usually neglected in magnetic materials because it is much smaller than the exchange interaction. But in some novel patterned magnetic structures this anisotropic long-range interaction plays an essential role. It strongly affects their properties. An example of these structures is the magnetic dot arrays produced by photolithography technology.
The calculations of the magnetostatic coupling energy are done for the two-dimensional square lattice of submicrometer-size cylindrical dots. The single-domain dots with in-plane magnetization are considered. The in-dot magnetic anisotropy is neglected. The magnetostatic energies of different configurations of the dot magnetizations are compared. The calculated ground state of the square lattice of the uniformly magnetized dots is a set of the degenerated non-collinear (antiferromagnetic) configurations of the dot magnetizations. The corresponding in-plane magnetization angles are $\varphi_1=\varphi$, $\varphi_2= -\varphi$, $\varphi_3=\pi+\varphi$, $\varphi_4=\pi-\varphi$ within the four-dot unit cell approximation. The energetically nearest configuration to the ground state is the ferromagnetic configuration ($\varphi_n=\varphi_0$). The critical field of the transition from these ground state configurations to the ferromagnetic ones reveals the fourfold anisotropy. This field depends strongly on the interdot distances and its typical value is 0.1 of dot saturation magnetization. The experimental data on the Fe, FeNi and Co submicron dot arrays are discussed.

We-PA127
INTERACTION EFFECTS IN A TWO-DIMENSIONAL ARRAY OF FERROMAGNETIC DOTS

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Periodical two-dimensional array of small ferromagnetic particles (dots) is interesting model system for investigation of mutual magnetic interactions and switching behavior. The applications of such patterned magnetic films for magnetic memory devices are promising.
In a given report the interaction effects in small clusters of magnetically soft ferromagnetic dots are studied by means of numerical simulation. The thickness of the particles is given by 20 ÷ 40 nm, the diameters are in the range of 200 ÷ 400 nm. Material parameters of the particles are supposed to be: saturation magnetization M_s = 500 ÷ 1000 G, exchange constant $A = 0.5\cdot10^{-6}$ erg/cm, anisotropy constant $K_1 = 10^2 \div 10^4$ erg/cm^3.
The hysteresis loop of two interacting particles is investigated in detail as function of distance between particle's centers at different values of diameter, thickness and saturation magnetization. The direction of in-plane external magnetic field is supposed to be parallel or perpendicular to the line connecting the particle centers. Analytical approximation is suggested for two-particle magnetostatic interaction effect. With the help of this approximation the behavior of small clusters of dots (3-5 particles) is investigated. Limiting case of single domain cylindrical dots arranged in square lattice is considered. Hysteresis loops of such dot array depend on in-plane magnetic field direction and reveal the four-fold anisotropy.
The support by the INTAS grant #97-31311 and by KIAS is gratefully acknowledged.

We-PA128
ROLE OF PARAMAGNETIC IONS IN FORMATION OF A TUNNEL INTERELECTRODE CURRENT ACROSS MOLECULAR WIRE

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The existence of ferrosulfur-, molybdenum-, and copper-containing electron-transfer clusters as well as various types of magnetically ordered chains gives further encouragement to carry out the studies of conductivity of low-dimensional molecular nanostructures (molecular wires) with paramagnetic ions being the bridging wire units. Such structures are thought to be perspective in molecular and magnetic electronics. Present communication represents theoretical results on control of elastic and inelastic tunnel current mediated by a molecular wire embedded between two microelectrodes when the wire contains a pair of paramagnetic ions with frozen angular momentum [1,2]. The existence of spin-filtration, spin-polarization, and electron blocking effects are predicted at strong magnetic field as well as the stair-case behavior of the current caused by exchange spin-spin interaction between the ions. Additionally, the spin-polarization effect observed earlier [3] in metal-ferromagnetic insulator-vacuum experiments on electron tunneling, is explained in the framework of dynamic spin-flip process accompanying the tunneling.

[1] Petrov E.G., Tolokh I.S., and May V.// Phys. Rev. Lett., 79, (1997), p. 4006.
[2] Petrov E.G.// Ukr. J. Phys., 43, (1998), p.1630.
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We-PA129
FERRITE NANOPARTICLES IN OXIDE GLASSES

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Faraday rotation (FR) spectral, field and temperature dependencies in oxide glasses with small additions of paramagnetic elements are investigated. One of the most peculiar property of these glasses is the spontaneous formation of ferrite nanoparticles during the additional thermal treatment. It is shown by X-ray diffraction that these particles have crystal structure similar to spinel structure, particles dimensions are about 8-20 nm. Thanks to these particles the large Faraday rotation is observed in the wide spectral region including the interval 1.3-1.5μm. It is important from the practical point of view.

The FR field dependencies are typical for ferrimagnetic or superparamagnetic substances in dependence on particle size. For the first case nonlinear FR field dependence with magnetic saturation and hysteresis is observed. For the second case FR field dependence is described satisfactory in terms of the superparamagnet theory. The critical particles size corresponding to the transition from one to another type of magnetic behavior is evaluated. For superparamagnetic particles unexpected strong FR increase at the samples cooling (more than twice in temperature interval 105-273 K) is observed.

The glasses investigated have very high magnetooptic figure of merit in the vicinity or 1.3-1.5μm. Besides some of them have large remanent FR value, i.e. they are transparent permanent magnets.

We-PA130
MAGNETIC BEHAVIOR IN THE VICINITY OF PERCOLATION THRESHOLD FROM GRANULAR TO DISCONTINUOUS Co/Ag LAYERED STRUCTURE

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Magnetic properties of Co/Ag multilayers have been studied in the vicinity of the two-dimensional percolation threshold (PT) from granular to discontinuous layered structures in Co/Ag multilayers with VSM and FMR. The percolation threshold is observed for about 5 Å of the nominal thickness of Co. Below PT [4 Å Co/20 Å Ag] samples reveal at room temperature superparamagnetic behavior typical of fine particles (10^3 – 10^4 Co atoms/particle) with non-negligible dipolar interactions. Above PT [6 Å Co/20 Å Ag] samples exhibit typical thin film behavior with the in-plane coercive field H_C=5 Oe. Annealing at 400 °C results in a transformation of the microstructures for both sets of the samples to a complex granular microstructure which can be seen as a collection of single-domain particles which exhibits cooperative behavior owing to the presence of antiferromagnetic interactions. The transformation has a significant effect on the magnetization curves, exhibiting remanence $M_r \approx 0.1 - 0.2\, M_S$ and $H_C \approx 20 - 30$ Oe (M_S – saturation magnetization), as well as on spin dynamics, particularly in a non-saturated state at the in-plane configuration. The FMR data are compared with the recent simulations of spin dynamics in cobalt-based multilayers [M.A. Wongsam and R. W. Chanterll, Phys. Rev. B **58** (1998) 12 207].

We-PA131

THEORY OF QUASI-UNIFORM STATES OF SMALL MAGNETIC PARTICLES

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We present analytical approach to the problem of quasi-uniform states in small nonellipsoidal ferromagnetic particles. For the particular case of square nanostructures we show that the well-known "leaf" and "flower" states may be described analytically by consistent approximations of the boundary problem solution. The thickness aspect ratio of the system where the phase transition between "flower" and "leaf" states takes place is calculated being in a good agreement with one obtained in [1] by computer simulation and by using of trial functions. In the linear limit the method proposed here coincide with the perturbation theory developed in [2]. Nonlinear corrections are estimated as well.

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We-PA132

TRANSPORT PROPERTIES OF ORDERED AND DISORDERED CoAl AND CoTi ALLOY FILMS

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The influence of structural disorder on the transport properties of CoAl and CoTi alloy films were investigated. CoAl and CoTi alloy films with a total thickness of about 100 nm were prepared by flash evaporation of the crushed alloy powders onto heated (730 K for the ordered state) and LN_2-cooled (150 K for the disordered state) substrates. Structural analysis of the films was performed by transmission electron microscopy. The resistivity measurements were carried out by using the four-probe technique in a temperature range of 4.2 - 300 K with and without an external magnetic field. The magnetic properties were also studied in a temperature range of 5 - 300 K. It was found that the temperature dependence of resistivity exhibits a significantly different behavior according to the degree of long range order. While both ordered and disordered CoAl films show a prominent resistivity minimum in the low-temperature region, the location shifts to a high temperature in the disordered alloy film. In case of CoTi alloy films, there is no prominent resistivity minimum. At the same time, the structural disorder leads to a change in temperature coefficient of resistivity from a positive to negative value. The behavior of the temperature dependence of these alloy films are not affected by the presence of external magnetic field. The results are analyzed in connection with the change in electronic structures and the possible transport mechanisms are discussed.

We-PA133

ASYMMETRICAL BEHAVIOR OF HYSTERESIS LOOPS IN R.F. SPUTERED Gd-Co FILMS WITH "OBLIQUE" ANISOPTROPY.

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In Gd-Co films as well as in Gd-Fe films (1) there is asymmetrical behavior of the angular dependence of characteristic reversal fields H_0, H_1 and H_2. The temperature in this case is constant. The asymmetry was consisted in occurrence of inverse hysteresis loops of the galvanomagnetic effects in some area of the angular dependence. It is the angular asymmetry of hysteresis loops. Also asymmetrical form of a dependence of characteristic magnetization reversal fields H_0 and H_1 concerning of compensation temperature was observed. In this case the measurements were carried out with the changes of temperature at constant orientation of a sample. The characteristic reversal field H_1 in certain region of temperature was absent. An additional hysteresis loop in this was degenerated. It is a temperature asymmetry of hysteresis loops. As well a field asymmetry at the certain orientation and temperature was observed. The different level of resistance and Hall voltage was traced for fields of various orientation. The magnetoresistance can be described by certain function $\Delta R/R \sim (\text{sign } H)\cdot F\cdot(M/Ms)$. The observed effect of the asymmetry are characteristic only for films with non perpendicular anisotropy and can be explained within of model exchange -coupled layers.

1.K.Okamoto. Dig. 20 th Conf. AIP . 113(1975).

We-PA134

INFLUENCE OF γ-IRRADIATION ON THE PROPERTIES OF THIN POLYCRYSTALLINE FILMS Ni_3Co

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Thin (50 - 200 nm) polycrystalline films of Ni_3Co were deposited on glass and mica substrates in vacuum with a base pressure of 10^{-4} Pa, using electron beam evaporation technique. Both as-prepared and annealed films were irradiated in vacuum by γ-quanta with energy 1.2 MeV from ^{60}Co source, the total dose being about 2.38×10^5 Cal/kg (10^9 Roentgen). Effect of γ-irradiation was studied on NMR spectra measured at T = 77 K and anisotropy field calculated from FMR investigations.

Broad NMR resonance spectrum centered at $f_{max} \cong 172$ MHz is observed in all as-prepared Ni_3Co films. Effect of γ-irradiation strongly depends on the preparation conditions. The films deposited on the substrates held at T_S = 150 - 250 °C show shift in f_{max} down to 169 MHz. Contrary, there are no visible changes for the films prepared at T_S = 400 °C and annealed at this temperature during 1 hour. Such difference is believed to be caused by the influence of γ-rays mainly on the grain boundaries, volume fraction of which reaches 50 % in the former films. As revealed further investigations, γ-irradiation gives rise to significant changes in dispersion of anisotropy field for the films prepared at T_S = 150 - 250 °C, while no such changes are observed in the recrystallized films. These results are in general compliance with magnetostatic model [1] connected anisotropy field in thin films with defect distribution in grain boundaries.

We-PA135

VIOLATION OF MAGNETIC ORDER IN THIN Cr FILMS AND $Cr_{1-x}Fe_x$ ALLOYS WHEN THEY CONDENCED IN VACUUM.

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Cr films preparation in vacuum up to 10^{-7} Torr in contrast to other metals (Cu, Ag, Au, Al) reveal the negative temperature coefficient of electro-resistance (TCR). Anomalies inherent for the bulk samples, that are connected with the antiferromagnetic ordering at the temperatures lower than Neel temperature (T_N), are absent at the temperature dependencies of R(T). In work [1] we compare the temperature dependencies of electro-resistance R, thermo electro moving force S, of bulk samples and Cr films with different thickness and also $Cr_{0.985}Fe_{0.015}$ alloys (structure incommensurable to spin density wave, SDW) and $Cr_{0.97}Fe_{0.03}$ alloys (structure commensurable to SDW). These alloys being in bulk state have a great anomalies at R(T) and S(T) at $T< T_N$. Cr films (thickness 10-500 nm) were prepared by ion plasma method (the residual vacuum was $6 \cdot 10^{-6}$ Torr, and after argon injection $6 \cdot 10^{-4}$ Torr) in a single run. It is shown that in all the cases while coming from the bulk to the thin film state anomalies at R(T) and S(T) at $T< T_N$ disappear, but TCR and TCS keep staying negative. Auger spectroscopy supported the presence of C, O, N impurities. After annealing in hydrogen at 550-560^0 C during 20 min. TCR sign becomes positive, but anomalies at R(T) and S(T) at $T<T_N$ do not renew. After direct current electro-transfer at T=280-450 ^{0} C during 6-20 hours we observe accumulation of C, O, N impurities on anode. Conclusion: small C, O, N impurities are the main reason of violating of ferromagnetic order while formation of thin Cr films and its alloys.

[1]. A.K.Butylenko, Met. Phys. And Adv.Techn. 2000, 22, N4.

We-PA136

MAGNETIC PROPERTIES OF $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ THIN FILMS AND POWDER GROWN BY A SOL-GEL METHOD

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$Nd_{1-x}Bi_xY_2Fe_5O_{12}$ (x = 0.0, 0.25, 0.5, 0.75, 1.0) thin films and powder were fabricated by a sol-gel method and their magnetic properties and crystal structures were investigated by using x-ray diffractometry, atomic force microscopy, scanning electron microscopy, Rhutherford back scattering(RBS), vibrating sample magnetometer(VSM), and Mössbauer spectroscopy. Films with homogeneous garnet phases were obtained from stock solutions spun on SiO_2/Si(100) substrates and fired at 600 ~ 800 ºC for 1 hour in air. Films had any preferred direction. X-ray diffraction patterns of $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ had only peaks of the garnet structure. The microstructure of the films with a square shapes consisted of 200 nm in size and 2 ~ 3 nm in surface roughness. The garnet of $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ had the largest saturation magnetization, 184 emu/cc, and the lowest coercivity, 27 Oe. The magnetic properties were strongly dependent on annealing temperatures. The results for magnetic properties indicated that the saturation magnetization was fixed; however, the coercivity decreased with increasing Bi concentration. The Mössbauer spectra were taken at various temperature ranging from 12 to 650 K. The isomer shifts indicated that the valence states of Fe ions for the 16(a) and the 24(d) sites had a ferric character. The Curie temperature of $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ decreased with increasing Bi concentration. Spin waves having long wavelengths were excited with increasing amount of Bi.

We-PA137

THE ONSET OF A LONG-RANGE FERROMAGNETIC ORDER IN AN ENSEMBLE OF SMALL FERROMAGNETIC PARTICLES

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We have studied the anmixing alloy $Cu_{64}Mn_9Al_{27}$ by X-rays and magnetic methods as well as small-angle neutron scattering. In the quenched state the alloy behaves as a typical spin glass. When the sample is further annealed, the formation of small particles with the stoichiometric composition Cu_2MnAl occurs. At high temperatures the alloy is a typical superparamagnet. After cooling the alloy undergoes the reentrant phase transition "paramagnetic-ferromagnetic-spin glass". It was shown on the example of the investigated alloy in decomposed state that the appearance of long-range ferromagnetic order in an system of superparamagnetic particles dissolved in nonmagnetic metallic matrix is due to the co-operative ordering of their magnetic moments.

We-PA138

MAGNETIC STATES IN QUASI-2D COMPOUNDS $Cr_{1/3-X}Ni_XTaS_2$ WITH COMPETING EXCHANGE INTERACTIONS

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A problem of lowest critical dimension (d_L) has a great interest in physics of disordered magnets with competing exchange interactions. But up to now there are some unsolved details. For example, computer calculations [1] show that for spin glasses (SG) 2(d_L(3. In experimental sense this problem is not resolved because demands of very complicate technology to fabricate ultra thin films of metallic SG. In additional it can be note that problem of d_L for reentrant SG (RSG) transitions has not be regarded.

In present work we present AC, DC magnetic and neutron scattering results on bulk quasi-2D intercalated dichalcogenids $Cr_{1/3-X}Ni_XTaS_2$.

It has been shown that:

(i) freezing magnetic states SG type exist in these compounds;
(ii) such a type of state is not the result of true phase transition. The freezing of spins takes place in very wide temperature interval up to 0K;
(iii) in investigated compounds RSG transition is absent.

We came to a conclusion that the dimension of above mentioned compound is lower than d_L of SGs.

[1] Binder K., Young A.P. // Rev. Mod. Phys., 58, (1986), p.801.

We-PA139

MAGNETOSTATIC WAVES DISPERSION AND DAMPING IN METALLEZED EPITAXIAL FILM OF YTTRIUM IRON GARNET

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Surface, backward and forward volume magnetostatic waves (MSSW, MSBVW, MSFVW) in the structure of metal-dielectric-yttrium iron garnet (YIG) film - gadolinium gallium garnet (GGG) substrate - metal are considered. MSW dispersion and damping are investigated in this structure under variation of dielectric layer thickness.
It was shown, that by the variation of dielectric layer thickness at is possible to control electrodynamically the initial section of MSSW and MSFVW dispersion.
The analysis of MSW paramagnetic absorption in the substrate of GGG have shown the essential increasing of wave losses with frequency and wave number increasing. It was observed, that paramagnetic absorption in GGG substrate is near 1/3 of MSW losses in YIG film strictly.
We considered also MSW in our structure under tangential magnetization and arbitrary angle between external magnetic field and wave vector directions. Boundary frequencies of MSSW and MSBVW in this case have been derived and analyzed. Field dependence of critical angle of surface MSW existence have been calculated too.

We-PA140

PRERARATION OF MAGNETIC HARD COBALT FILMS

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With the aim of increasing the information recording density, thin magnetic layers are widely used as recording medium nowadays. One of perspective methods of their manufacturing is the electrodeposition by programmed pulsed current. Cobalt films were obtained from simple sulfate electrolyte in the range of the pulse repetition rate of 30-1000 Hz. The pulse relative duration was changed from 2 to 32. Magnetic measurement have shown that cobalt films had a pronounced anisotropy of their magnetic properties. Under certain conditions in choosing the current pulse parameters the direction of easy magnetization <0001> is in the sample plane. This fact is in a good agreement with the results of the *X*- ray structure study which reveal that, as a rule, the texture [1010] is formed in cobalt films produced by pulsed electrolysis. The pulse repetition rate affects the changes of both residual magnetization and coercive force with increasing the pulse repetition rate in the range of 30-1000 Hz decrease of residual magnetization from 750 Gs till 100 Gs and decrease of coercive force from 80 kA/m till 12 kA/m are observed. The increase of coercive force can be connected with β-Co appearance and decrease of the crystallite size in electrolytic sediment. Such suggestion is approved by results of the *X*-ray structure and TEM studies. The measurement have shown that 'sandwich' structures formed by alternative α- and β- Co layers had good magnetic properties. Such structure possess higher coercive force and high residual magnetization. Modification of magnetic properties of cobalt films can be performed by changing the α- and β- Co quantitative ratio.

We-PA141
SURFACE FERROMAGNETIC ANOMALIES IN THE Fe-Ni AND Co-Ni ALLOYS

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The influence of magnetic ordering on the structure, composition, dynamic and emission characteristics of the surface layers oriented along (100), (110), and (111) faces of Co - Ni and Fe - Ni alloys is systematically investigated with the used of Low - Energy Electron Diffraction (LEED), Auger Electron Spectroscopy (AES), and Ionization Spectroscopy (IS) complemented with the technique of layer-by-layer restoration. A number of ferromagnetic anomalies in the surface layers of the above-mentioned alloys is observed. The magnetic contribution into effective Debye temperature, relaxation of interlayer distances, relative changes of the anharmonic component of the interatomic interaction forces and surface composition are defined. An assumption about the relation of these effects is made.
On the basis of the results obtained we can conclude that in the vicinity of T_c most of important characteristics of solid are changed [1]. For example, break- down of the magnetic ordering over the Curie temperature results in increase of the intensity of elastically reflected electrons due to essential dominance of scattering processes on the magnetic moment fluctuation in the vicinity of phase transition point over scattering on thermal oscillations, step-wise change of the interplanar distances due to the vanishing of the magnetic contribution into effective Debye temperature, increase of anharmonicity of thermal oscillations. Investigation of the interrelations between the above-mentioned effects is of particular interest.

We-PA142
VORTEX LIKE MICROMAGNETIC STRUCTURES IN THIN SOFT TYPE FERROMAGNETIC STRIP

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Investigation of the non uniform magnetization distributions in thin magnetically soft ferromagnetic strip under external magnetic field is important for development of new type of sensors based on the giant magneto-impedance effect, [1]. Various possible types of stable magnetization distributions in a long ferromagnetic strip are studied in this work by means of numerical simulation. The material parameters of the strip are as follows: saturation magnetization $M_s = 550$ G, exchange constant $A = 0.5\cdot10^{-6}$ erg/cm, effective anisotropy constant $K_1 = 10^4$ erg/cm^3. Magnetic field is applied along the long side of the strip.
The multi-vortex states with different number of vortexes, various quasiuniform states as well as the magnetization disributions of the Van den Berg's type are studied in the strips with a thickness 40 nm, width 240, 360 and 480 nm and length up to 2 micrometers. Magnetization curves and hysteresis loops are obtained depending on the strip's length. It is found out that the hysteresis loops parameters for the strips having lengthes larger or lower than the characteristic single-domain size differ considerably.
This work was supported by means of ISTC grant #766-98.

[1] Antonov A., Gadetsky S., Granovsky A., et. al. // Physica A241 (1997) 414.

We-PA143

ROLE OF MAGNETOSTATIC PRESSURE AT FORMATION OF NEW SPIRAL DOMAIN STRUCTURE IN THE FERRITE-GARNET FILMS

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Conditions of coexistence of two domain phases - the spiral domain (SD) and the lattice of cylindrical magnetic domains (LCMD), observed in the uniaxial ferrite-garnet films in absence of a magnetic field [1] are studied experimentally. It is proved that the phases are in balance when their magnetostatic pressures are equal. As the pressure of LCMD increases with reduction of the lattice period $\bar{a}$ ($\bar{a} = a/h$, where h is the film thickness) [2] and the pressure of SD grows with increase of radius $\bar{R}$ ($\bar{R} = R/h$) [3], the condition of balance is carried out only at the certain values $\bar{a}$ and $\bar{R}$. It is displayed experimentally that SD, surrounded by a CMD lattice, forms in the film at $2.0 < \bar{a} < 2.7$. The new kind of SD - spiral curtailed (winded up) as a loop (a spiral-loop) forms at $\bar{a} < 2.0$. As well as SD the spiral-loop is surrounded with a CMD lattice. However the spiral-loop has two external ends in difference from SD, who has the internal and external end. The influence of a constant magnetic field on the behavior of a spiral-loop is investigated.
It is shown theoretically the possibility of formation of that or other kind of spiral domains determined by the CMD structure density (or the same as by LCMD pressure).

[1] Lamonova K.V., Mamalui Yu.A., Siryuk Yu.A. // FTVD 6, 1 (1996), p.33.
[2] Zablotskii V.A., Lamonova K.V., Mamalui Yu.A., Siryuk Yu.A. // FTVD 6, 2 (1996), p.34.
[3] Mamalui Yu.A., Lamonova K.V., Soika E.N. // J.Phys. IV France **8**, (1998), p.393.

We-PA144

MAGNETIC PHASE AND MICROSTRUCTURE OF Fe-Zr FILMS EPITAXIALLY GROWN ON MgO(001)

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Some basic magnetic properties of nanocrystalline materials such as Fe-(Ta, Si, Al, Zr)-N nanocrystalline thin films were investigated to understand their excellent soft magnetic properties. Among those the magnetic behavior of Fe-Zr film is so complex and still under argument about 4-10 at% Zr-Fe films. In this paper, Fe-Zr films with Zr content 0 - 13 % are epitaxially grown on MgO(001) substrate by an rf magnetron sputtering method to investigate the magnetic phase and anisotropy.
All Films showed four-fold symmetry of anisotropy when measured by torque magnetometer, vibrating sample magnetometer (VSM) and ferromagnetic resonance (FMR). With increasing Zr content, lattice parameter increased up to 4 at. % and increased up to 5.5, and then increased again. In FMR films with 4 and 8 at. % showed single absorption peak while films with 5.5 and 12 at. % showed more than 3 peaks, which agreed well with x-ray diffraction result and cross sectional image and selected area diffraction patterns of transmission electron microscopy. From these it could be concluded that Fe-Zr formed solid solution up to Zr content of 4 at. % and Zr atoms in films with 12 at. % Zr were extruded to grain boundary and form a second phase, which was not identified yet.

We-PA145

TRANSITION ANTIFERROMAGNETIC LAYER IN EPITAXIAL Fe FILM ON LiF SUBSTRATE.

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By a method of vacuum condensation (001) simple crystal Fe films with reversal magnetization along [110] directions (laid in film plane) and displaced histeresis loop were prepared. The loop keeps this shape when the temperature of substrate-film system is raised up to 200°C. With increasing of reversal magnetization field over 200 Oe the hysteresis loop takes usual form.
A technological peculiarity of such film preparation was introducing of small quantity of chlorine into residual gases of vacuum chamber. Issue from existence of antiferromagnetic $FeCl_2$ we make a supposition about the presence of some transition antiferromagnetic layer between Fe film and LiF substrate consisted of Fe and Cl atoms. We can contend that the layer has cubic crystal lattice and is high temperature metamagnetic.

We-PA146

ANISOTROPY OF DOMAIN STRUCTURE INDUCED BY INCLINED IRRADIATION OF MAGNETIC FILM

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The irradiation of smooth film surface by large fluence of heavy ions shapes a relief on it. At inclined irradiation it has a form of regions, prolate along irradiation direction, with characteristic heights of 1-100 nm.
In the present work the influence of relief formed by inclined irradiation (Ar, 20 keV), on domain wall (DW) direction distribution ($f(\varphi)$) in a uniaxial film of substituted ferrite garnet was studied. The dependences $f(\varphi)$ were investigated near the boundary between irradiated and unirradiated regions (φ - orientation angle of DW relative to the boundary). Before the irradiation the equilibrium domain structure was a labyrinth one (LDS), the preferential directions of domain walls were absent. It was revealed that in an unirradiated part of a film near the boundary all orientations of DW were present. In this area the investigated distribution had small anisotropy. It was revealed in the form of two maximums on $f(\varphi)$, which are connected with orienting influence of boundary and features of LDS. In area with relief equilibrium domain structure has a sharp anisotropy, it is a stripe domain lattice. In it 95 % of DW are parallel to a direction, formed by irradiation. The remaining 5% of DW form the second maximum of distribution, which is caused by dislocations. Thus, the formation of relief leads to equilibrium domain structure type change. The possible mechanisms of relief influence on orientation of DW are: suppression of instability bending of domain walls or anisotropy of the contribution of surface defects to a coercive force.

We-PA147

IRREVERSIBILTY OF MAGNETIZATION PROCESSES IN ULTRATHIN Co FILMS SANDWICHED BETWEEN Pt LAYERS.

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Magnetization reversal processes and domain structures in ferromagnetic ultrathin Pt/Co(t)/Pt sandwiches, deposited on Si/SiN substrates, were investigated by magneto-optical polar Kerr magnetometry and microscopy. The spin reorientation transition of the magnetization M, from out-of-plane to in-plane, in such structures deposited on Si/SiN takes place at t=1.6nm. We have limited the present study to samples which exhibit perpendicular anisotropy and square hysteresis loops. The magnetic field H was applied along easy axis. In all experiments the sample was first saturated using H<0 field. Applying a H>0 field, magnetic aftereffect (strongly increasing with H) was observed for any sample. The demagnetized state may be reached via this process by switching off the field when M=0. Irreversibility of magnetization processes was studied starting from this demagnetized state. It reveals differences between magnetization dynamics for: (i) H>0 and H<0, starting from this M=0 state; (ii) initial magnetization curves for H>0 and H<0. Irreversibility becomes stronger with the Co film thickness. Irreversibility was correlated with domain geometry.
This work was partially supported by ESF NANOMAG Program and Polish Grant No 2P03B06515.

We-PA148

MBE GROWTH AND MAGNETIC CHARACTERIZATION OF ULTRATHIN COBALT FILMS ON DIFFERENT SUBSTRATES

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The aim of this work was to optimize the preparation conditions and the growth of high quality epitaxial ultra-thin Co films with perpendicular magnetic anisotropy. Ultra-thin cobalt layers (with different thickness smaller than 20 A) were deposited by molecular beam epitaxy (MBE) on two types of substrates: (i) sapphire (11-20) with/without seed layer and (ii) Au/Ag(111) epitaxial buffer layers grown on mica. The structure of the films was checked in-situ with scanning tunneling microscope (STM), reflection high-energy electron diffraction (RHEED) and Auger spectroscopy and ex-situ with both STM and atomic force microscope (AFM). Procedures for improvement of the sample surface quality were developed. The dependencies of the average grain size and the terraces width on annealing temperature were derived for Mo buffer layer and Au thin film grown on it. By the epitaxy of 30 A Au films on Ag(111)/mica, the Au surface quality of the underlying Ag buffer layer was obtained. Magnetization processes and magnetic domain structures of Co films were investigated using magnetooptical magnetometry and microscopy.
This work was partially supported by ESF NANOMAG Programme and Polish Grant No 2P03B06515.

We-PA149

PROPERTIES OF A NEW KIND OF STRUCTURE: LATTICE OF SPIRAL DOMAIN.

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A great diversity of systems where the spirals and lattices of spirals are formed has been mentioned [1]. The study of properties of given domain structure (DS) type in magnetic ferrite - garnet films with uniaxial anisotropy essentially supplements a general picture. Spiral domains lattices (SDL) were formed by a pulse field from initial labyrinth structure with a plenty of germs as twirled stripes. The film heating to a Neel point is experimentally shown to lead to the germs destruction and impossibility of SDL formation. If the saturation field is applied to the film with the labyrinth structure and then decreased to zero, the SDL is formed, because the germs keep safe. SDL's particular feature was the complete absence of bubble: the massive of the interrelated spirals occupied all the film area. The influence of the film temperature T and field H on the SDL properties has been investigated. The strictly hexagonal SDL was shown to be created in a narrow interval of positive fields out of which the lattice domains symmetry distortion was developing. Is has been obtained that the SDL was characterized by the greater stability while changing T/H compare to the single spiral domains (SpDs) in a bubble lattice environment and clusters SpDs of the same sizes coexisting with the clusters of bubble. The lattice domains had some optimum size and the number of coils N are not exceeding 10. Dependences N on the formation field (at fixed T) and the temperature dependences of same parameter (at fixed H) contained "a plateau". The increase both H and T formation resulted in reduction of N; the increase of the fixed sizes T, H lead to the reduction of the plateau area. Parameters (period of SDL structure and the domain width) at changing T, H were the same as parameters to strip DS.

[1] Assenheimer M., Steinberg V.// Europhysics News - 1996.-v. 27, №4.- P.143-147.

We-PA150

MAGNETIC ANISOTROPY EFFECT IN THE ULTRA SOFT MAGNETIC $Fe_{75.5}Zr_{8.3}N_{16.2}$ THIN FILM

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The ultra soft magnetic properties of the $Fe_{75.5}Zr_{8.3}N_{16.2}$ nanocrystalline thin film prepared by the rf reactive sputtering method in $Ar+N_2$ atmosphere were investigated. Because the thin film is so soft, the anisotropy of the sample could hardly be observed. In this study we have measured the angular dependence of the incremental permeability in conjunction with the magnetic anisotropy in the $Fe_{75.5}Zr_{8.3}N_{16.2}$ nanocrystalline thin film. The thin film annealed at 450°C with an external field shows the distinct anisotropy results. The longitudinal incremental permeability ratio(LPR) measured at various frequencies increases with the increment of the ac drive field and decreases rapidly up to zero at near 4 Oe with the increment of the external dc field for all measurements. LPR curves show a single peak pattern since the easy axis is parallel to the direction of the measurement in contrast to the transverse incremental permeability ratio (TPR) where the double peak pattern appears due to the anisotropy effect. The large changes of LPR and TPR curves in low external fields can be useful for magnetic sensor applications.

We-PA151

REMANENT STATES AND HYSTERESIS LOOPS OF THIN FERROMAGNETIC PLATELETS

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Recently the properties of planar structures of ferromagnetic dots, i. e. small ferromagnetic particles arranged in a two-dimensional periodic array, attract considerable interest [1]. The sizes of the particles are typically much larger than the corresponding single-domain size. Therefore, it is important to study the actual magnetization distribution of the particles in the ground state and to reveal the effect of in-plane external magnetic field.

In a given report the numerical simulation of nonuniform magnetization distributions is carried out for thin soft type ferromagnetic square platelets with dimensions 480x480x40 nm and flat disks of diameter 400 nm. These samples can be considered as the elements of the planar array of ferromagnetic dots. Material parameters of the particles are supposed to be: saturation magnetization $M_s = 550 \div 800$ G, exchange constant $A = 10^{-6}$ erg/cm, anisotropy constant $K_1 = 10^2 \div 10^4$ erg/cm^3.

For the particles with the material parameters and dimensions mentioned the magnetization curves as well as the hysteresis loops are calculated for the in-plane magnetic field parallel both to the square side and to the square diagonal. For all of the cases considered the magnetization curling state is the ground state of the particle. The characteristic magnetic field necessary to push vortex from the particle turns out to be of the order 800 – 1000 Oe.

This work was supported in part by means of INTAS grant #97-31311.

[1] Kreuser S., Prugl K. Bayreuther G. and Wiess D. // Thin Solid Films 318 (1998) 219.

We-PA152

EFFECT OF ANNEALING ON MAGNETIC PROPERTIES OF $Fe_{81}Mo_7Zr_7B_5$ AND $Fe_{81}Y_7Zr_7B_5$ THIN FILMS.

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A great deal of magnetoelectronic devices requires magnetic materials with soft magnetic behaviours. Amorphous and nanocrystalline thin films fulfil the above conditions. However, in many applications the key question is the thermal stability of the soft magnetic properties.

In this paper we present comparative studies of structural and magnetic properties of Fe-rich alloy films containing either Mo or Y elements. The samples were prepared by flash evaporation of the pulverised alloys onto glass substrates cooled with liquid nitrogen at ultra-high vacuum 2×10^{-7} Pa. Magnetic parameters such as coercive field H_c, magnetic induction B_s and spontaneous Hall coefficient, R_s, were measured by Kerr and Hall effects. Effective magnetization, M_{eff} and resonance linewidth ΔH_{pp} were determined by FMR. These parameters were measured after annealing at temperatures ranging from RT to 823K. In the same temperatures the changes of the structure were observed by TEM.

The connection between the magnetic properties and the changes of the grains dimensions was confirmed.

We-PA153

RELATION BETWEEN MAGNETIC ORDER AND SEGREGATION AT (111) SURFACE OF BINARY DISORDERED FCC ALLOY

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Relation between magnetic order and segregation at the (111) surface of a binary disordered fcc alloy was theoretically studied making an allowance for the differing energies of chemical and exchange interactions in atomic pairs AA, BB, and AB. The calculation was performed within the framework of the Heisenberg model, assuming that the alloy magnetization was due to contributions from single magnetic electron of each atom. The possibility of the existence of ferro- and antiferromagnetism was taken into account by introducing two equivalent magnetic sublattices. The equilibrium equations determining the temperature dependence of the surface atomic concentrations and spontaneous magnetizations of the sublattices were derived from the condition of minimum free energy. The temperatures of the phase transition (the Curie and Neel points) are determined. The surface Curie and Neel temperatures, the equilibrium values of the surface concentration, and the spin order parameters were calculated on a computer using a simple iterative method. The possibility of a magnetic reconstruction of the surface was studied, where by the surface becomes antiferromagnetically ordered for the ferromagnetic bulk and vice versa. it was shown that upon the magnetic reconstruction, a ferrimagnetic surface state appears under the influence of the bulk magnetism at temperatures below the temperature of the bulk magnetic transition.

We-PA154

THE DEPENDENCE OF CURIE TEMPERATURE FOR MULTILAYER FILMS OF Co/Cu ON THE THICKNESS OF COPPER LAYER AND WAVES OF CHARGE DENSITY.

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1. The exchange interaction between uncoupled electrons in neighboring Co layers of multilayers can be determined from Coulomb interaction of the electrons and is inversely proportional to the thickness d of Cu layer and its dielectric permeability ε. Because the energy of interaction is equal to thermal energy at the Curie temperature, the dependence of ε(d) can found from the experimental dependence of the Curie temperature on d [1]. ε is of the order 10-100 which is corresponded to literature data for dipole crystals.
2. The fourth Maxwell equation allows finding the electric charge density ρ depending on d by means of numerical differentiation of function ε(d). Then ρ distribution takes the form of spatial wave, i.e. the wave of charge density.
3. The comparison of the dependence ρ(d) and the experimental dependence $I_s/I_{s0}(d)$ [1] (spin density waves) shows the curves of these dependencies are similar with similar maxima and minima, e.g. minimum I_s/I_{s0} and negative ρ maximum are observed at the same value of d.

[1] P.D.Kim, U.H.Chen, I.A.Turpanov et al.//Letters in JTEP,v.64,1996,p.341

We-PA155

SPIN-DEPENDENT QUASIPARTICLE TUNNELING IN JUNCTION SUPERCONDUCTOR-ISOLATOR-FERROMAGNETIC

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The influence of Andreev reflection of quasiparticles in transparent tunnel junctions of superconductor-isolator-ferromagnetic on electric-current transport is studied within the framework of the Blonder-Tinkham-Klapwijk (BTK) model. It is obtained that current and signal-to-noise ratio can be increased for the memory cell by using in it the double-barrier tunnel junction ferromagnetic-isolator-superconductor-isolator-ferromagnetic instead off the usual tunnel junction ferromagnetic-isolator-ferromagnetic.
The evolution of non-linear (tunnel-type) current-voltage characteristics with increasing of the junction transparency is described.

We-PA156

MAGNETIC SUSCEPTIBILITY OF POWDERS LAYERED OF DISELENIDES TRANSITIONAL METALS OF A VARIOUS DISPERSIBILITY

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The temperature associations of a specific magnetic susceptibility (77 ÷300K) layered of diselenide of d-transitional metals V and VI of groups of a periodic system are investigated. It is shown, that diselenides of various structural types (2H-TaS_2 and 2H-MoS_2) and the conductivities (metal and semiconducting) at a dispersion exhibit various magnetic properties. For 2H-$NbSe_2$ (powders micron of sizes), possessing a metal type of conductivity, is characteristic Pauli a paramagnetism. In nano dispersed a status (size of particles 25 ÷140 nm) it is diamagnetic. For micron of powders 2H-$MoSe_2$, 2H-WSe_2, being semiconductors, the diamagnetism is characteristic and at a dispersion up to nano crystal of sizes (15 ÷95 nm) it turns in a Pauli paramagnetic material. The reasons of modification of magnetic properties of layered diselenides of d-transitional metals of groups V and VI are considered at their dispersion up to status of a nano crystal.

We-PA157

STUDY OF $Pr_{1-x}K_xMnO_3$ PEROVSKITES BY ELECTRON SPIN RESONANSE

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We have investigated the magnetoresistance and electron spin resonance (ESR) of the $Pr_{1-x}K_xMnO_3$ (x=0, 0.05, 0.1, 0.15) perovskites in temperature range 77-300 K
The strong composition and temperature dependences of electron spin resonance spectra at 9.4 GHz were observed. Single resonance line with large linewidth and asymetric line shape was observed in the ESP spectra. The increase of K contents in $Pr_{1-x}K_xMnO_3$ leads to large shift of the ESR field in spectra to high field region on 300 mT.
The observed temperature dependence of the magnetoresistance and ESR spectra are connected with paramagnetic - ferromagnetic transition in perovskite manganites [1].

1.J.Hejtmanek et al. J. Appl. Phys. **81** (1997) 4975

We-PA158

COEXISTENCE OF THE SPIN GLASS AND THE GIANT MAGNETORESISTIVITY IN THE NEW COMPOUND $CuCr_{1.6}Sb_{0.4}S_4$

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The compound $CuCr_{1.6}Sb_{0.4}S_4$ makes a solid solution of the ferromagnet $CuCr_2S_4$ with the metallic conductivity and of the antiferromagnet $CuCr_{1.5}Sb_{0.5}S_4$ with the high negative Curie-Weiss paramagnetic temperature Θ_{C-W} equal to 156 K. Magnetic susceptibility was measured at very weak magnetic fields with the aid of both the AC and DC method in the temperature range of 4.2 K – 300 K. It turns out that we deal here with the spin glass. Magnetization was measured at very high both stationary (up to 14 tesla; temperature range: 4.2 K – 300 K) and pulsed (up to 38 tesla; temperature range: 1.6 K – 35 K) magnetic fields. From these measurements it follows, that we deal here with the long-range antiferromagnetic ordering accompanied by the strong short-range ferromagnetic coupling. The resistivity measurements both at magnetic field (stationary: at 10 tesla and the temperature range 4.2 K – 300 K; pulsed: at 38 tesla and the temperature range 1.6 K – 35 K) and without it (temperature range: 4.2 K – 300 K) point to the semiconductivity and the giant negative magnetoresistivity of the compound under study. It turns out that the maximum value of the giant negative magnetoresistivity is equal to 74% at 38 Tesla and 3K.

We-PA159

ENHANCED FARADAY ROTATION IN Ce-SUBSTITUTED YTTRIUM IRON GARNET FILMS DEPOSITED BY PULSED LASER DEPOSITION

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It is well known that in Ce-substituted Yttrium Iron Garnet films produced by liquid-phase epitaxy [1], the Faraday Rotation, FR, values increases, especially in the visible region, with increasing Ce-content. This is specially so in the wavelength range 0.65 to 0.5 μm. However, such a strong enhancement around 0.5 μm was not observable in the absorption spectra for the same films. In order to gain further insight into the role of Ce substitution in YCeIG films, we have fabricated them by Pulsed Laser Deposition on single crystal GdGaO substrates using a Nd-YAG Laser. The effect of oxygen ambient partial pressure during deposition has also been investigated and characterized extensively. We find well oriented films are obtained around 50 mTorr oxygen pressure.

Measurements of the energy dependence of Faraday rotation show significant enhancements in the FR-spectra centered around 700 and 440 nm respectively. The possible role of Ce^{3+} ions and the 4f-5d transitions in the observed FR-enhancements will be discussed.

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Thursday, June 8, 2000

Th-IA01
EMR STUDIES OF SOME DOPED La-BASED MANGANITES

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The method of electron magnetic resonance, namely, electron paramagnetic (EPR) or ferromagnetic resonance (FMR) is fruitfully used in last years for the investigation of the colossal magnetoresistive manganites. Very recent results regarding EPR/FMR studies of polycrystalline $La_{1-x}A_xMnO_3$ where A = Pb, Sn, Zn, as well as these obtained on poly- and single-crystalline $La_{1-x}(Na_x)Mn_{1-y}O_3$ and $La_{1-x}Mn_{1-y}O_3$ samples are presented in this lecture.
The main features observed for the resonant spectra of all the samples are noted: a) gradual change of the broad asymmetric line of FMR to narrow line of EPR with temperature T; b) coexistence within certain temperature intervals FMR and EPR signals, as well as the signals of FMR and ferromagnetic antiresonance; c) minimum of the linewidth in the vicinity of 1.1 T_c and its liner broadening above this temperature; d) double integrated intensity of the signal obeys Arrhenius low above 1.1 T_c; e) specific effect of the non-resonant surface microwave absorption. The results obtained on poly- and single-crystalline samples are compared. The presence of intrinsic magnetic inhomogeneities in all of the manganites under consideration is emphasized. The disputable problems on this field are mentioned.

Th-IA02
THE INSULATING PHASE OF MANGANITES

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In the manganese compounds the largest value for the CMR arises when the resistance rises to particularly high values above T_c. Hence it is important to understand the high temperature regime where there is a growing amount of short range order. This is an interesting problem as there is high doping but also strong coupling.
This will be best considered in a real space formalism. Composite polarons are considered which consist of several sites with coherent electron hopping between them and associated lattice distortions [1]. Electron transfer between the clusters is incoherent leading to thermally activated hopping. The data is shown to agree with the steps that are observed in the magnetic susceptibility just above T_c [2].
The theory is extended to consider the lightly doped materials in which coherent ferromagnetism occurs but the electron transfer is by hopping. This gives a description of the ferromagnetic insulating state that occurs for low doping.

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Th-OA01
PRESSURE EFFECTS ON THE MAGNETIC AND STRUCTURAL PROPERTIES OF LAYERED MANGANITES

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Pressure effect on transport, magnetic and structural properties of layered $(La_{0.6}Nd_{0.4})_{1.2}Sr_{1.8}Mn_2O_7$ manganite will be discussed. The application of pressure results in the shift of the Mn atoms from the center of each bilayer towards the adjacent bilayer. The analysis of the compressibility data for individual Mn-O bonds shows that the observed shift of the Mn atoms involves mainly the charge redistribution within the $3d_z^2$ axial orbital. The overall compressibility along the c axis is "absorbed" by the decrease in the inter-bilayer spacing while the distance between the apical oxygen atoms on the opposite sides of each bilayer remains unchanged. The decrease in the inter-bilayer spacing and the shift of the Mn atoms within each bilayer result in the increased magnetic and electronic coupling between the adjacent bilayers along the c axis. The layered $(La_{0.6}Nd_{0.4})_{1.2}Sr_{1.8}Mn_2O_7$ manganite is the first material to show a 2D to 3D crossover under pressure.

Th-OA02
MAGNETIC PROPERTIES OF THE MAGNETORESISTIVE Cu-($SmCo_5$)-Fe HETEROGRANULAR ALLOYS

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Granular heterogeneous alloys, consisting of magnetic nanograins of Co, Fe or Ni, dispersed in a nonmagnetic metallic matrix, as Cu, Ag, Au, exhibit giant magnetoresistance (GMR) effect [1,2]. This effect is very sensitive to the grain structure and also to the existence of multiple magnetic phases [3,4]. The present work deals with the magnetic properties of some Cu-($SmCo_5$)-Fe melt-spun ribbons submitted to suitable annealing treatments by means of Mössbauer spectrometry, magnetic and magnetoresistance measurements. It is shown that the existence of several, interacting magnetic phases, influence the magnetoresistive properties of such granular magnetic alloys. The analysis of the correlation between the magnetization and the magnetoresistance results, proves the existence of size distributed magnetic nanograins exhibiting dipolar interactions between them. A significant GMR effect is reported in such RE-containing nanogranular alloys.

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Section A

Th-OA03
CHARGE ORDERING AND INSULATOR-METAL TRANSITION OF EPITAXIAL $Pr_{1-x}Ca_xMnO_3$ FILMS

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The temperature dependence of resistivity for $Pr_{1-x}Ca_xMnO_3$ thin films prepared by a pulsed-laser-deposition method was measured in a temperature range of 4.2 - 300 K. The X-ray diffraction patterns indicate that all the films have a *c*-oriented texture and an in-plane epitaxial relationship between film and substrate ($LaAlO_3$) of [001]PCMO//[001]LAO. The analysis also reveals that the as-deposited films were strained and the difference in lattice constant between as-deposited and annealed films turned out to be 0.7 %. The lattice strains suppress the charge ordering which is observed for these compounds at a certain temperature. The charge-ordering energy gap was estimated to be 77.5 meV from the experimental data. It was shown that the temperature dependence of resistivity for some films changes abruptly near the antiferromagnetic ordering temperature, below which the resistivity follows the metallic-like behavior. The experimental data have been analyzed in the framework of the modern theoretical approaches for the transport mechanism of the colossal-magnetoresistance materials. A new explanation for the thermally activated conductivity is proposed on the basis of the phase-separation model.

Th-OA04
EVOLUTION FROM FERROMAGNETIC ORDER TO CLUSTER GLASS BEHAVIOR IN $La_{0.7-x}Y_xCa_{0.3}MnO_3$ MANGANITES

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Magnetic measurements were performed on polycrystalline samples of $La_{0.7-x}Y_xCa_{0.3}MnO_3$, with $x = 0$, 0.07, 0.10 and 0.15. Substitution of La^{+3} by smaller Y^{+3} ions reduces the average ionic radius of the La site $\langle r_A \rangle$, which decreases the electronic bandwidth and causes a reduction of the ferromagnetic (FM) transition temperature . Low field dc magnetization (M) and ac susceptibility (X_{ac}) measurements on the studied compounds clearly show a change from a steep FM transition for the $x = 0$ and 0.07 samples, to a cusp-like anomaly for $x = 0.10$ and 0.15. This indicates an increase of the antiferromagnetic (AFM) super-exchange interactions for higher Y doping, which led us to look for spin-glass-like properties in this system. Indeed, the shape of the field cooled and zero field cooled M data, frequency dependence of X_{ac}, as well as M vs. H measurements, are consistent with the appearance of a cluster-glass phase, clearly observed in the $x = 0.15$ sample. Moreover, we have performed magnetic relaxation measurements (M vs. t), which shows a slow alignment of FM clusters with the external applied field. Aging effects, typical of spin glasses, were also observed. At moderately high fields (H $\approx$ 5000 Oe) the glassy signatures of the system disappear, indicating that the external field stabilizes the FM state. Our results clearly show that the magnetic phase diagram of La substituted manganese perovoskites, often plotted as a function of the average ionic radius of the La site (proportional to the tolerance factor t), must include a metallic cluster-glass-like phase, which gradually appears within the ferromagnetic ordered phase.

Th-IA03
NEW PHENOMENA RELATED TO THE COLOSSAL MAGNETORESITANCE EFFECTS IN MIXED VALENCE MANGANITES

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The huge intrinsic magnetoresistance (Colossal Magnetoresistance, CMR) found in mixed-valence manganites has as origin the existence of a metal-insulator transition. Usually, this transition is accompanied by a para-ferromagnetic transition. In the paramagnetic phase the formation of dynamic phase segregation in the form of magnetic polarons provides the mechanism for carrier localisation (1). The insulator state can also be achieved in the antiferromagnetic state or when the long-range ferromagnetic interaction is not extended across the whole sample, giving rise to the existence of static phase segregation in which metallic ferromagnetic clusters coexist with insulating paramagnetic, antiferromagnetic or spin-glass regions (2,3). In such insulating regions, charge ordering can also be present. The application of a magnetic field can increase the size of the ferromagnetic clusters up to a critical field at which they start to percolate and, consequently, the carrier mobility is strongly increased producing giant magnetoresistance and magnetostriction (4).

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(2) J.M. De Teresa et al. Phys. Rev. Lett. **76** (1996) 3392.
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Th-OA05
RADIO FREQUENCY MAGNETIC FIELD PENETRATION THROUGH LANTHANUM MANGANITES

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The penetration of the radio frequency electromagnetic waves through the materials with granular structure, such as the bulk sintered manganites, has the specific peculiarities. The presence of porous and the two-phase structure of sintered materials are resulting in the frequency dependence of high frequency conductivity and the unusual frequency dependence of skin depth. The penetration of radio frequency electromagnetic field through the plates fabricated from the bulk sintered polycrystalline La-Pb-MnO_3 and La-Y-Ba-MnO_3 manganites have been studied for the conditions when the thickness of the plates was either much less, or of the same order than that of the skin depth. The measurements were carried out for the frequency range from 50 kHz till 90 MHz at two mutual orientations between the high frequency $\vec{H}_{\sim}$ and *dc* external $\vec{H}$ magnetic fields: with $\vec{H}_{\sim} \,||\, \vec{H}$, and $\vec{H}_{\sim} \perp \vec{H}$. The frequency dependence of skin layer depth was obtained experimentally. The sensitivity of the transmission coefficient to variations of the *dc* external magnetic field was also determined. These results can be considered as the physical basis for possible device applications of radio frequency electromagnetic field penetration through the bulk polycrystalline sintered manganites.

Th-OA06
A THEORY OF COLOSSAL MAGNETORESISTANCE Pr- AND Nd-BASED MANGANITES

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Basic properties of the Pr- or Nd-based manganites differ from those of the La-based manganites drastically: At $T = 0$ the former remain insulating for any dopings by Ca, Sr etc, but a magnetic field H causes a metamagnetic transition from an antiferromagnetic state to a ferromagnetic state simultaneously with the transition from an insulating state to a highly-conductive state. The following model is proposed: the doped hole ground states in LaMnO and in ReMnO (Re = Pr, Nd). are of quite different types. Whereas in LaMnO the hole corresponds to Mn^{4+}, as La^{4+} are forbidden, in ReMnO it corresponds to Re^{4+} which are allowed. The overlapping of the hole orbitals for the neighboring Re ions should be small as they occupy inner 4f states. Due to the polaronic effects and fluctuations of the impurity potential, the hole remains localized at one of the Re ions in ReMnO whereas the Mn^{4+} hole in the external 3d state is spread around Ca, Sr ions in LaMnO.
A magnetic field can cause transition of the holes from the Re ions with formation of the Mn^{4+} ions. Then, like in LaMnO, the Mott transition becomes possible at dopings sufficiently large, and the Mn hole band arises. Its bottom lowers with the magnetization. Hence, the number of holes went over from the Re ions to Mn ions increases with the magnetization. On the other hand, increase in the number of the Mn holes increases the magnetization due to the indirect exchange via them. For this reason, the joint action of the H and hole Re-Mn transfer causes the metamagnetic transition simultaneously with the insulator-to-metal transition.

Th-OA07
NOVEL TYPE OF ORBITAL ORDERING : COMPLEX ORBITALS IN THE COLOSSAL MAGNETORESISTANCE MANGANITES

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Orbital effects play very important role in the properties of many magnetic oxides, in particular in the colossal magnetoresistance manganites. Orbital ordering is known to exist in undoped $LaMnO_3$, in the charge ordered state in $R_{(1-x)}A_{(x)}MnO_3$ (R = La,Pr,Nd ; A = Ca,Sr) at x=1/2 and around x=1/8,in the stripe phases in overdoped manganites. However it is always thought to be absent in the ferromagnetic metallic regime at the optimal doping ($0.2 < x < 0.5$). The materials in this regime are essentially cubic (if we ignore tilting of MnO_6 octahedra),and there is no static Jahn-Teller deformations. However the orbital degeneracy of $Mn^{(3+)}$ ions is still present. I suggest that there exist quite different type of orbital ordering in this case: "ferromagnetic" ordering of complex orbitals (linear combinations of x^2-y^2 and z^2 orbitals with complex coefficients). Such an ordering is stabilized by the kinetic energy of doped electrons (holes), so that this state is a ferromagnetic metal. Despite perfect orbital ordering, the material with this orbital occupation remains cubic; the first nontrivial moment connected with this ordering is the magnetic octupole one. Several consequences of this novel type of orbital ordering will be discussed.

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Section A

Th-OA08
LOW-TEMPERATURE MINIMUM OF RESISTIVITY AND MAGNETORESISTANCE IN CERAMIC MANGANITES: AN INTERGRAIN TUNNELING MODEL VERSUS EXPERIMENT

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One of the key features of colossal-magnetoresistive (CMR) manganites is a strong dependence of the conductivity on their structure: polycrystalline or single-crystalline one. For example, the high values of magnetoresistance at low temperatures and only its weak maximum in the vicinity of Curie point T_c, notable shift of a temperature of maximum of zero-field resistivity from T_c and the broadening of this maximum are characteristic for ceramic samples. There exists a consensus in literature that the above peculiarities of ceramics, originates from spin-polarized intergrain tunneling.
At the same time, the explanation suggested recently attributes the origin of a shallow minimum observed at $T < 50$ K in a zero-field resistivity of CMR ceramics to an interplay of Coulomb interaction (CI) between carriers and disorder inherent to these systems. In this presentation we show that, although the CI mechanism describes the resistivity minimum at $H = 0$, it fails to predict how the resistivity varies in a finite H. A proposed model of tunneling-assisted conductivity between antiferromagnetically coupled ferromagnetic grains, fairly describes experimental data on low-temperature conductivity of CMR ceramic manganites.

Th-IA04
FEMTOSECOND MAGNETO-OPTICS: SPIN DYNAMICS IN FERROMAGNETIC LAYERED SYSTEMS

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The ultrafast spin dynamics in ferromagnetic materials has been become an issue of great current interest. New time-resolved magneto-optical techniques have been developed which allow for studying the magnetic relaxation after a sudden perturbation on time scales down to the femtosecond regime. Several groups have reported on a quenching of the magnetization of ferromagnetic transition metals, like nickel and cobalt, within hundreds of femtoseconds after applying an intense heating laser pulse. This ultrafast demagnetization, being faster than the electron-lattice thermalization, has puzzled its researchers.
In this presentation two crucial issues will be addressed: Firstly, are we sure what is measured in these type of experiments? Is it pure magnetization dynamics, or do optical artifacts, like *dichroic bleaching*, play an important role? Secondly, what are the spin scattering sources that give rise to the ultrafast magnetization? The importance of spectroscopic studies and phase resolved experiments (measuring Kerr-rotation and ellipticity explicitly) for addressing the first issue will be emphasized. In order to isolate the spin scattering mechanisms, we performed experiments on Cu(111)/Ni(0-8 nm)/Cu wedges, measuring the dynamics as a function of Ni thickness. We were able to demonstrate that at least during the first picosecond a direct relation between the magneto-optical response and the magnetic moment – which is assumed to exist in almost all of the recent publications– does not hold. The true demagnetization in nickel is found to depend strongly on extrinsic parameters, like the interface quality, but can be as fast as picoseconds. Simple models to describe the observed phenomena will be discussed.

Th-IA05

NONLINEAR MAGNETO-OPTICS

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Magnetization induced second harmonic generation (MSHG) is a new nonlinear magneto-optical technique that combines interface sensitivity with huge magneto-optical effects. These effects are due to the simultaneous breaking of inversion symmetry (at interfaces) and time-reversal symmetry (by the magnetization).

Because most magnetically ordered materials are centrosymmetric in their bulk form, MSHG is a particularly interesting probe to study the magnetization structure of the interfaces in magnetic multilayer systems. Using MSHG, we have found e.g. that the spin orientation at the interface of CoNi/Pt multilayers can be different from the bulk due to specific preparation conditions. Due to both very high magneto-optical contrast and interface sensitivity, fine details of magnetization reversal become visible with the MSHG imaging that are not detectable by usual magneto-optics. MSHG also appears to be highly sensitive for the step induced anisotropy in magnetic thin thin films grown on vicinal surfaces.

In addition, effects of interface annealing and oxidation can be observed in situ, which is of great importance for sensor multilayer sructures. By using phase sensitive spectroscopic MSHG experiments, the spin-dependent interface density of states can be probed, as was recently demonstrated in a study on a Ni(110) surface. This is of great importance for the understanding of e.g. the spin dependent tunnel current in magnetic tunnel devices. Finally, the use of fs laser excitation allows the probing of ultra fast magnetization dynamics, using pump-probe techniques. Recent results of this will be discussed.

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Th-OA09

NONLINEAR OPTICS OF MAGNETIC NANOPARTICLES

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Since 1988's experimental observation of magnetization induced second harmonic generation (MSHG) nonlinear optics of magnetic materials has been intensively studying in a variety of systems. First, nonlinear magneto-optical Kerr effect (NOMOKE) and nonlinear-optical Faraday effect were discovered in thin iron garnet films [1]. Recently, giant NOMOKE was observed in Co nanoparticles in granular films exhibiting giant magnetoresistance effect (GMR) [2].

Magnetic and nonlinear optical effects as GMR, spin dependent electron scattering, surface enhanced SHG, giant NOMOKE and correlation between their mechanisms are of fundamental importance. In this paper, we survey the results of our recent experimental studies of the giant NOMOKE and surface enhanced SHG in magnetic nanostructures as Co-Cu, Co-Ag and CoFe-Al_2O_3 granular films exhibiting GMR. The results of SHG and NOMOKE studies of thin films of yttrium-iron garnet nanoparticles prepared by layer-by-layer self-assembling (LSA) techniques are presented. The amazing correlations between nonlinear optical properties and GMR effect are observed in Co-Ag granular films. MSHG studies of YIG nanoparticles reveal giant NOMOKE which is observed in nonmetallic magnetic nanostructures for the first time.

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Section A

Th-OA10
LASER BEAM ASSISTED KERR MICROSCOPY FOR INVESTIGATIONS OF NEW MAGNETO-OPTICAL STORAGE LAYERS

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Although magnetic domains of ~100 nm can be written by magnetic field modulation the magneto-optical readout is not possible in a standard way. One method which overcomes the optical diffraction limit is the "center aperture detection for magnetically induced superresolution" (CAD-MSR). For this technique at least two layers are required, a recording layer and a readout layer, which must have in-plane magnetization at room temperature and perpendicular at elevated temperatures [1,2]. A layer system consisting of GdFeCo/TbFeCo, which shows such a behaviour, has been prepared by rf-sputtering. Temperature dependent measurements indicate that the magnetization of the GdFeCo layer switches from nearly in-plane to perpendicular above 350 K. A domain structure was created in the TbFeCo layer and was observed from the TbFeCo side in a special Kerr microscope [3]. Then the sample was turned and, viewing from the GdFeCo side, the domain structure was visible with weak contrast. Hence, the small perpendicular component has copied the domain structure from the underlying layer. Then a laser beam was focussed onto the sample. When the temperature in the laser spot exceeded 350 K the magnetic contrast increased corresponding to the increase of the remanent magnetization of the GdFeCo layer. In conclusion the readout process, which is necessary in CAD-MSR, can be demonstrated by direct observation in a μm scale.

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Th-OA11
MAGNETIC AND MAGNETOOPTICAL PROPERTIES OF $Bi_3Fe_5O_{12}$ (100) THIN FILM PREPARED BY PULSED LASER DEPOSITION

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Completely substituted bismuth iron garnet single crystal films ($Bi_3Fe_5O_{12}$: BIG) have been synthesized onto $Gd_3(ScGa)_5O_{12}$ (100) substrates by pulsed laser deposition (PLD) technique. The KrF (λ=248nm) excimer laser has been used to ablate stoichiometric ceramic BIG target.
The deposition rate has been reached 0.8 μm/hour that is the most rapid growth of BIG in comparison with the previous reports.[1,2] The XRD θ-2θ scan of the film shows good (100) oriented film and the FWHM of the rocking curve shows 0.06 degree. In the ϕ scan, the position of the 4 sharp Bragg peaks from (4010) plane of the film are in good agreement with those of the (4010) substrate's peaks. The saturation magnetization is about 1100 Gauss while the coercive field is below 40 Oe. The Faraday rotation angle at 630nm has been found to be -7.5 deg/μm, which is larger than the previous reports on Faraday rotation in BIG films grown by PLD technique.[2,3]

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Th-OA012

MAGNETO-OPTICAL INVESTIGATION OF Fe(x) /Pd (30Å) MULTILAYERS

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Multilayers Fe (x)/ Pd (30Å) (6 Å ≤ x ≤ 30 Å) has been investigated by using transverse Kerr effect (TKE) method in an energy range from 1,3 to 3,6 eV. The oscillations of TKE with changing of the thickness of Fe layer has been observed. It was discovered that the value of period of oscillations is equal to 7 Å. The nondiagonal elements of permeability dielectric tensor ε_2' have been calculated from measurements of TKE and optical constants for all multilayers. It has been found that the magnitude $\varepsilon_2' \cdot \omega^2$ (where ω - frequency of incident light), proportional to the interband density of states oscillated with the same period of 7 Å and the character of this oscillations was similar to the oscillations of Kerr effect. It should be emphasized that there were many distinctions between oscillations amplitudes of the saturation magnetization and TKE. The obtained results have been explained by the influence of finite-size effects on electronic structure of multilayers.

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Section B

Th-IB01
INVESTIGATION OF MAGNETO-ELASTIC DOMAINS IN EASY-PLANE ANTIFERROMAGNETS

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Layered dihaloids of iron group elements ($NiCl_2$, $CoCl_2$, $CoBr_2$ etc.) are easy plane (EP) antiferromagnets (AF). The spontaneous reduction of in-plane symmetry takes place in these crystals under magnetic ordering due to magneto-elastic interaction. As a result spatial degeneration for the antiferromagnetic vector **L** direction in the easy plane leaves. In the spectrum of low frequency antiferromagnetic resonance appears a distinctive gap. However, it was obtained at the studies of these antiferromagnets magnetostriction that a macroscopic spontaneous deforming of the plane of crystal as whole does not appear in the absence of external magnetic field $\mathbf{H}_{\perp}$ applied in the base plane. This is connected with formation of multidomain structure in AF crystal. Spontaneous deformations of the easy plane in each of the domains are present. But they are differently directed and mutually indemnify for the sample as whole. Earlier AF domains in given crystals were discovered by neutron diffraction method. The in-plane magnetic field converted a crystal in the one-domain state with $\mathbf{L}\perp\mathbf{H}_{\perp}$. A deforming of the plane of crystal as whole appears herewith. A multidomain structure is restored practically reversible at the removal of the field.
It is grounded that given domain structure is connected with elastic long distance forces under spontaneous magnetostrictive deformation of EP AF. Such domains are to be considering as magneto-elastic ones.

Th-IB02
ALLOYAGE INFLUENCE ON THE STRUCTURE AND MAGNETIC PROPERTIES OF 3d – 4f INTERMETALLICS

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The majority of 3d-4f intermetallics allows the variation of their chemical composition (alloyage) without (or with) variation of the crystal structure type. This property is widely used both for development of new magnetic materials and for clarifying the nature of fundamental interactions in 3d-4f intermetallics.
The survey of main results obtained in the Institute of Metal Physics in this rather spacious extensive field of investigations will be presented. The following questions will be outlined especially:
1. The structure variations of 3d-4f intermetallics under the influence of alloyage.
2. The influence of substitutions in 4f subsystem on magnetic properties of 3d-4f compounds.
3. The relation between substitutions in 3d subsystem and magnetic properties of 3d-4f intermetallics.
4. Interstitial solid solutions on the base of 3d-4f intermetallics and their magnetic properties.

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Section B

Th-OB01

A SIMPLIFIED DOUBLE-EXCHANGE MODEL IN THE DYNAMICAL MEAN-FIELD APPROXIMATION

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Simplified double-exchange model including transfer of the itinerant electrons with spin parallel to the localized spin at the same site and the indirect interaction J of kinetic type between localized spins is comprehensively investigated. The model is exactly solved in infinite dimensions. The exact equations describing the main ordered phases (ferromagnetic and antiferromagnetic) are obtained for the Bethe lattice with infinite coordination number in analytical form. The exact expression for the generalized paramagnetic susceptibility of the localized spin subsystem is also obtain in analytical form. It is shown that temperature dependence of the uniform and the staggered susceptibilities has deviation from Curie-Weiss law. Itinerant-electron concentration dependence of Curie and Neel temperatures is discussed to study instability conditions of the paramagnetic phase. Anomalous temperature behavior of the chemical potential, the thermopower and the specific heat is investigated near the Curie point. It is found for J=0 that the system is unstable towards temperature phase separation between ferromagnetic and paramagnetic states. A phase separation connected with antiferromagnetic and paramagnetic phases can occur only at J>Jc=0.159W where W is the bandwidth. Temperature phase diagram including the phase separation between ferromagnetic and antiferromagnetic states is given for the case of J<Jc.

Th-OB02

SUPERCONDUCTIVITY WITH ANGULAR DEPENDENT COUPLING: STRIPES, COULOMB REPULSION AND ENHANCED T_c

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Recently a convincing experimental evidence has been rapidly emerging proving the reality of the stripe existence in underdoped HTSC's [1]. We have analyzed the effect of intrinsic doping inhomogeneity and the presence of stripes in high-T_c superconductors on coupling Λ by using a simple analytically solvable model with an angular dependent $\Lambda(\phi)$ represented by a square-well form. We have found that the introduction for certain angles of the Coulomb repulsion V, increasing the "contrast" $\Lambda + V$ or the depth of the angular modulation of $\Lambda(\phi)$, leads to a remarkable enhancement of T_c. This effect can be optimized by combining attractive ($\Lambda < 0$) and repulsive ($\Lambda > 0$) interactions along stripes and perpendicular to them. In the overdoped regime, due to the doping of the interstripe areas, the added charge suppresses the existing stripicity and strongly reduces the angular modulation of $\Lambda(\phi)$. The zero stripicity fully restores the 2D character of the CuO_2 planes and the jellium-like doping of the full suppression of T_c.

[1] Physics Today, June 1998, p.19 and Refs. Therein to articles by J. Zaanen, V. J. Emery, S. A. Kivelson ; V. J. Emery, S. A. Kivelson , J. M. Tranquada // preprint cond-mat/9907228 (1999).

Th-OB03

METALLIC CONTRA HOPPING CONDUCTIVITY IN $La_{1-x}Sa_xMnO_3$ FOR X≤0.175

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The complex dielectric function $\varepsilon_1+i\varepsilon_2$ of $La_{1-x}Sr_xMnO_3$ has been investigated for concentrations $0.1 \leq x \leq 0.175$ near the metal-to-insulator transition. Quasioptical spectroscopy technique were employed for frequencies 100 GHz $\leq \nu \leq$ 1100 GHz and temperatures 10 K $\leq T \leq$ 300 K. Both, the dielectric constant ε_1 and the conductivity $\sigma_1 = \varepsilon_0\varepsilon_2\omega$ of all samples were found to increase on cooling through the magnetic ordering transition. From this observation and from the analysis of the frequency dependencies we conclude that the charge carriers are localized in a broader range of the phase diagram than generally accepted. We show that hopping or tunneling between localized states dominates the conductivity for Sr concentrations $x \leq 0.15$ and temperatures $T < 300$K. Even for $La_{0.725}Sr_{0.175}MnO_3$ the localization effects are observed at least 10 K below the magnetic phase transition. Finally, the dielectric constant is observed to diverge on approaching the metal-insulator transition.

Th-OB04

INFLUENCE OF MAGNETIC FIELD ON THE D.C. AND A.C. ELECTRODEPOSITION OF COBALT

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Electrodeposition of metals or alloys on the cathode of an electrolytic cell takes place under the influence of E-field on the metallic ions (M+) between the electrodes. The electrochemical deposition of metals in the nanopores of anodic alumina is carried out by a.c. electrolysis. In this paper we report the idea of using a magnetic field to influence the electrodepostion of ferromagnetic material films on the substrates and nanowires in the pores of anodic alumina. The cobalt films electrodeposited on copper substrates from a sulphate bath under the influence of magnetic field (> 0.5T) show fine needle like grain structure and consist of mostly hcp-Co as comapred to the spherical grains and fcc-Co deposited without field. Application of the magnetic field, on the a.c. electrolysis to deposit cobalt in the nanopores of anodic alumina, enhances the pore filling. The effect of magnetic field on the properties such as morphology, crystallographic structure, texture and magnetization of the electrodeposited cobalt films and nanowires is investigated and the mechanism discussed. This idea may be used to modify the morphological, structural, mechanical and magnetic properties of the electrodeposited films and nanowires of ferromagnetic materials in general.

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Section B

Th-IB03

SUPERCRITICAL DYNAMICS OF A DOMAIN WALL IN ULTRATHIN FERROMAGNETIC FILM

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The dynamics of domain wall (DW) in ultra thin magnetic film in the absence of dissipation is investigated. It is shown that the motion of the DW can be divided into three phases. The first phase is characterized by the energy that does not exceed some critical value $\varepsilon<\varepsilon_W$. The output angle of the magnetic moment from the plane of DW is increased and the velocity of the DW grows with the energy. At $\varepsilon=\varepsilon_W$ the velocity reaches its maximum value (Walker's velocity), and further weakly depends on the energy of the DW. The second phase of the DW motion exists in the energy range $\varepsilon_W<\varepsilon<\varepsilon_c$. Low-frequency oscillations appear in this phase. The oscillations frequency at $\varepsilon\to\varepsilon_W$ vanishes according to the linear law $\omega\sim\varepsilon - \varepsilon_W$. The output angle of magnetic moment from the plane of DW continue to increase until it reaches the value ($\pi/2$) in the point ε_c, i.e. the DW becomes Neel's type. At this point the frequency of the oscillations vanishes again, while their amplitudes remain finite. We deal with the motion of vibration Neel's DW in the third phase (when $\varepsilon>\varepsilon_c$). The frequency of DW oscillations increases with the energy according the square root law $\omega \sim \sqrt{\varepsilon - \varepsilon_c}$ in this phase.

Th-OB05

CALCULATION OF THE LOW LYING MAGNETIC EXCITATIONS WITHIN DENSITY FUNCTIONAL THEORY

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The adiabatic theory of spin density waves is developed on the basis of spin density functional theory. The wavenumber dependent exchange constant matrix is obtained from spin density functional calculations with constrained moment directions. The central assumption considers a fast electronic and a slow magnetic time-scale, and postulates negligible correlation of the fast motion between different ionic sites, which allows to introduce the concept of adiabatic magnetic moments formed by the itinerant electrons and to construct effective adiabatic spin Hamiltonian. The parameter-free calculated magnon spectra for Fe, Co, and Ni are in good agreement with available experimental data. In the case of Fe, they show strong Kohn anomalies.
For the description of the magnetic excitations in the rare earth metals the localized 4f electrons are described in the frameworks of Russel-Saunders scheme. Their interaction with itinerant subsystem is described via on-site exchange. It is found that finiteness of this interaction plays an essential role for the magnon dispersion, and a simple Heisenberg model for the total site spin does not apply. The obtained magnon spectra are in semi-quantitative agreement with experimental data, where the latter are available.

Th-OB06
ELECTRONIC STRUCTURES AND MAGNETIC PROPERTIES OF NEAR-EQUIATOMIC Fe-Ti ALLOYS

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The electronic structures and magnetic properties of near-equiatomic Fe-Ti alloys were studied by using the first-principles energy-band structure calculations. TB-LMTO-ASA method within the local-spin-density approximation was used. For non-equiatomic alloys, a defect-specified supercell method was employed. A formation of the antistructure Fe atom and its cluster plays an important role to determine the ferromagnetic behavior of the disordered equiatomic alloy or off-stoichiometric Fe-rich alloys. A small but considerable amount of charge transfer from the Ti to Fe atom is crucial to the structural stability and the magnetic properties of the alloy system. The magnitude of the charge transfer is strongly correlated with the magnetic behavior; the larger the charge transfer, the smaller the magnetic moment of the Fe atom. A sharp peak in the calculated density-of-states curve near the Fermi level grows as the Ti concentration decreases, indicating a strong localization of the states, which gives a better understanding of the change in physical properties upon an order→disorder transition. The sharp peak was originated from the minority spin band of the antistructure Fe atom.

Th-OB07
MONTE CARLO DYNAMICS OF THE SPIN-GLASS BEHAVIOR IN $Fe_{0.25}Zn_{0.75}F_2$

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Results of a Monte Carlo dynamics simulation on the three-dimensional randomly-diluted Ising antiferromagnet $Fe_{0.25}Zn_{0.75}F_2$ indicate that its spin-glass-like phase [1] at zero magnetic field is characterized by the presence of finite antiferromagnetic domains, separated by random vacancies, but strongly correlated in time. In a microscopic description, the glassy behavior is a consequence of the combined action of short-range interactions and the presence of strong density fluctuations in the highly diluted regime, close to the percolation threshold [2]. By studying the aging of the system, we also find that its dynamics is in agreement with experimental results and predictions of stochastic models of spin glasses. In particular, the data collapse of the autocorrelation function evidences a power-law time decay with the scaling variable t/t_w, where t_w is the waiting time before the measurements.

[1] Montenegro F.C., Rezende S.M., and Coutinho-Filho M.D. // J. Appl. Phys., 63, (1988), p.3755; Europhys. Lett., 8, (1989), p.383; Montenegro F.C., Leitão U.A., Coutinho-Filho M.D., and Rezende S.M. // J. Appl. Phys., 67, (1990), p.5243; Montenegro F.C., King A.R., Jaccarino V., Han S-J., and Belanger D.P. // Phys. Rev. B, 44, (1991), p.2155.
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Th-OB08
A SPIN GLASS STATE IN $CuGa_2O_4$

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The magnetic state of the cubic spinel single crystal $CuGa_2O_4$ has been investigated by dc and ac magnetic susceptibility in magnetic field up to 50 kOe and at frequencies from 0.1 up to 1 kHz, and by muon spin relaxation (μSR). The susceptibility shows a peak at the temperature T_f about 2.5 K. Below T_f the dc susceptibility depends strongly on the magnetic history of the sample, namely the field cooled (FC) and zero field cooled (ZFC) curves separate at T_f, with the FC metastable magnetic state with larger value of the magnetization. These results, together with the frequency dependence of T_f indicate the presence of magnetic interactions resulting in spin-glass dynamics. The temperature dependence of the specific heat shows the broad maximum at the temperature T_f .
The μSR measurements was carried out in the temperature range 0.6 - 4.5 K. These measurements shows also that the ground spin state of $CuGa_2O_4$ is the spin glass with the temperature of transition paramagnetic-spin glass T_f about 2.5 K. The experimental results are analyzed with help of autocorrelation functions for disordered spin systems and by the computer Monte Carlo simulation.

Th-IB04
THE ESSAYS ON DYNAMIC OF MAGNETIC (SPIN) SYSTEMS

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Some rather popular aspects of magnetic dynamics are discussed with slightly unusual pointrs of view. Considered are the macroscopic motion equations of various forms – from Landau-Lifshitz (LL) to Vlasov-Ishmukhametov (VJ) ones. An unexpected result is: LL equations being written in the terms of the spin (angular momentum) densities of sublattices are justified for magnetic with an anisotropic g-tensor. The latter is introduced through the Zeeman energy only. Specifically, this may be important for RE ortoferrites. The application of VI equations simplifies perceptibly the calculations of spin-wave spectra.
Then a very simple algorithm (for "pedestrians") is formulated to devide the dynamic magnetic variables into independent spin-wave representations. Selected are three types of modes: pure antiferromagnetic (existing even for a ferromagnetic exchange magnetic structure), quasiantiferromagnetic (with a single magnetization component) and quasiferromagnetic (with two magnetization component) ones. Some spin-wave representations and corresponding motion equations to be found in antiferromagnets give longitudinal oscillating (besides relaxating) modes.
The problems have been partly discussed in the paper [1]

[1] Turov E.A., Kolchanov A.V., Men'shenin V.V., Mirsaev I.F., Nikolaev V.V.// Uspehi Fiz. Nauk, 168, (1998), p.1303

Th-IB05
NANOSCOPIC TO MESOSCOPIC MAGNETISM: AN UNIFIED ELECTRONIC PICTURE

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Ab-initio band structures calculations are the most precise tools to describe the electronic and magnetic structure of solids. However despite tremendous computational developments, theses methods are restricted to a small number of inequivalent sites. Recent success in the determination of the magnetic anisotropy of thin films and multilayers will be given as further research directions. However the systems experimentally studied display larger scale of inhomogeneity. Obviously there is a need to have a unified picture to describe the electronic structure of systems of any size.
The semi-empirical tight-binding hamiltonian provides a good alternative. Recently a fully self-consistent scheme has been developed and used to describe itinerant non-collinear magnetism. Up to few hundreds of inequivalent atoms can be considered. The intrisic problem of the low convergence has been tackled. For the Fe/Cr system which has been experimentally widely studied, it is clearly found that topological defects lead to non-collinear magnetic arrangements with a spatial extension over the nanometer scale. The possible relations towards micromagnetic approaches will be addressed.

Th-OB09
ELECTRONIC STRUCTURE OF Fe-Ni COMPOUNDS AT THE EARTH'S CORE CONDITIONS

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One of the most important unresolved problems of geochemistry is the chemical composition, structural and magnetic properties of the Earth's interior. An attempt is made to coherently understand the structure of the Earth's core on the basis of *ab initio* approach.
Electronic structure calculations of the ground state of FeNi and $FeNi_3$ compounds at the Earth's core conditions are performed by a self-consistent first-principles fully relativistic spin-polarized linear muffin-tin orbital method (SpRLMTO) [1].
Non-spin-polarized calculations of the ground state of some ordered Fe-Ni alloys with the inner core mass density of 13 g/cm^3 for several concentrations of Fe show that in the density-of-states functions of the nonmagnetic FeNi and $FeNi_3$ the pronounced peaks in the vicinity of the Fermi level are observed. Spin-polarized calculations for these compounds have been performed, which predicts a pure itinerant weak ferromagnetism with magnetization value of 73.7 CGSM for FeNi and 123 CGSM for $FeNi_3$. The effect is explained in terms of the band structure theory.
Total energy and pressure for two representative crystal structures are studied as the functions of compression in the range of the geophysical estimates of the inner core mass density between 12 and 14 g/cm^3. We find that $FeNi_3$ is likely to be energetically accessible in this range.

[1] Krasovskii A.E. // Phys. Rev. B, **60**, (1999), p.12788.

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Th-OB10
MULTILEVEL PACKINGS FOR MAGNETIC SEPARATORS AND FILTERS FORMED OF MAGNETIC PARTICLES.

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The effective processing of mediums can be achieved by magnetic separators or filters (MSF) with application of multilevel packings (MP) to MSF [1]. Development of ways of formation of MP, allowing to receive a plenty of the necessary sizes and a mutual arrangement of separate elements of MP in uniform technological operation.
The ways of formation of MP are considered with the pulse of a constant magnetic field to the particles of Ni (3 - 15 microns). It is established that the formation of MP with the various characteristic sizes of separate elements is possible depending on the value of constant field. The ordered arrangement of elements of MP was received with use of magnetic matrix. It is revealed that reproduced formation of the two-level structure consisting of enclosed quasi-periodic substructures with clusters of the different sizes is possible from enough large initial clusters. Such structures can be used for formation of MP for magnetic filters and separators.

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Th-OB11
SUSCEPTIBILITY MEASUREMENTS AND NÉEL RELAXATION

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A colloidal suspension of cobalt particles has been studied by means of complex relative susceptibility measurements, $\chi(\omega) = \chi'(\omega) - i\chi''(\omega)$, as a function of the frequency (100 Hz - 10 GHz) and temperature (4 – 300 K).
The frequency dependent measurements reveal the presence of both relaxation and resonance mechanisms, with the resonance behaviour occurring in the GHz range. For a colloidal suspension of Cobalt particles, a loss-peak corresponding to the maximum of the $\chi''(\omega)$ component is shown to be due to Néel relaxation and from this data a value for the precessional decay time, τ_0, which is a pre-factor of Brown's equations for Néel relaxation, is evaluated .
The temperature dependence of the in-phase component of the susceptibility, $\chi'(\omega)$, measured at 100 Hz exhibits a maximum at around 250 K which shifts to higher temperatures with increasing frequency. The transition of the Co-particles to the superparamagnetic state are additionally supported by the temperature dependencies of the ZFC and FC magnetisation measurements.

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Section B

Th-OB12
HARD AND SOFT AMORPHOUS MAGNETIC MATERIALS BASED ON MICRO ROTARY-ENCODER

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Due to the significant helical magnetic anisotropy, the twisted $Fe_{77.5}Si_{7.5}B_{15}$ amorphous glass-covered wires (AGCW) present a large Matteucci effect, having a magnitude V_M that can reach up to several hundreds of mV [1]. The idea of our rotary-encoder was to use instead of the magnetizing coil used in the classical Matteucci experiments, the ac field produced by the in-rotation magnetic dipoles of a rotary-encoder rotor. Since the frequency of the Matteucci signal f_M is equal with the frequency of excitation field, we will have that $f_M = \omega \times n/2$, where ω is angular speed of the rotor and n is the number of magnetic dipoles. In our experiment we used as sensitive element a 10 μm in diameter of 45 deg twisted $Fe_{77.5}Si_{7.5}B_{15}$ AGCW. Also, by gluing together in a radially geometry a 100 pieces of 20×500 μm^2 cross section amorphous precursor $Ne_8Fe_{86}B_6$ ribbons, we obtained a 1.8 mm in diameter hard magnetic rotor. The radially ribbons' placement was carefully controlled in order to obtain an alternated distribution of magnetic dipoles. The main advantage of this rotary–encoder consists in the fact that does not requires any power supply or supplimentary electronics, the output signal that comes directly from the ends of the sensitive micro-wire being significant enough to can be measured by a frequencemeter.

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Th-PB001

THE ROLE OF IMPURITY STATES IN GARNET MAGNETIC SEMICONDUCTOR FILMS

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Magnetic properties and charge carriers transport in $Y_3Fe_{5-x}Si_xO_{12}$ films are studied. The electrical conductivity versus temperature in the range 77 – 600 K, magnetic field up to 1.8 T, electric field up to $6{\bullet}10^3 V{\bullet}cm^{-1}$, frequency in the interval from 0 to 10^4 Hz are measured.
The conductivity concentration dependence of activation energy E_a ($T>T_c$) decreased from 0.8eV to 0.3eV and correlated with concentration dependence of nuclear relaxation time. These data demonstrate the origin of impurity band because of overlap of impurity states on the base of Si^{+4} and nearest Fe^{2+}-Fe^{3+} ions with dynamic changed valence. The conductivity-frequency relation depends on temperature and concentration impurities. At $f - f_{crit}$ $\sigma(f)$ increased as $\sigma = kf^S$ at S=0.75. The value of f_{crit} decreased at temperature and concentration of Si^4 increasing. It means that transport of carrier, occurs near edge of conductivity band and controled by impurities states.
The nonlinear V-J-dependencies at high concentration of Si^{4+} which was absent at low temperature was found. The analysis showed that electric field (F) dependence of conductivity $\sigma(F)$ was explained by field ionization of impurity states and described by the Frenkel-Pool law $\sigma=\sigma_0\exp(\beta f^{1/2})$. Magnetoresistivity of this films depend on orientation of **M**, **n** and **J** but didn't be in excess of 0.5%.

Th-PB002

DOMAIN-ACOUSTIC PROCESSOR FOR RECORDING AND PROCESSING THE COMPLICATED INFORMATION SIGNALS

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The main tendency of the development of modern information systems is the use of complicated signals with their subsequent correlation processing. The domain-acoustic processor (DAP) designed on the base of ferrite elements of garnet and spinel structure is described in the present work. The DAP can process signals in real time, has long-time memory, provides multiple reproduction of the memorized signal and its correlation processing as well as the possibility to process several signals with different frequencies simultaneously. The processor is characterized by the memory stability to external influence and does not need power supply.
The DAP has the following characteristics: the sizes are $15\times15\times70$ mm^3, the range of the operating frequencies is $1\div10$ MHz, dynamic range is 80 dB, the time of the signal storing is practically unlimited. The DAP provides the correlation processing of such classes of complicated signals as pulse sequences with binary Barker code, m-sequences, polyphase sequences and linear-frequency-modulated signals as well as separating such signals from noises. The designed DAP can be widely used in defectoscopy of the construction materials, medical ultrasonic intrascopy and modern communication technics as well as in other electronic systems using correlation processing of the complicated signals.
The work is supported by STCU grant #391.

Th-PB003
MAGNETOSTATIC WAVES IN ANNEALED EPITAXIAL FERRITE FILMS

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Epitaxial ferrite films are known to be weakly inhomogeneous because of the peculiarities of their growth. That causes the changes of the characteristics of magnetostatic waves (MSW) propagating in the films. When annealing the films Ga ions diffuse from substrate to ferrite. As the result the inhomogeneity becomes greater [1]. Therefore different profiles of magnetization can be created depending on the regime of heat treatment. In addition the FMR linewidth ΔH also varies through the thickness in this case. In the present work dispersion, decay and energy flux distribution of the MSW in annealed epitaxial ferrite films are calculated for different regimes of heat treatment. Three types of MSW such as surface (MSSW), forward volume (MSFVW) and backward volume (MSBVW) are examined. The results of magneto-optic measurements of the annealed ferrite films are used for determining the magnetization and ΔH profiles. The calculations for the MSSW are carried out with the use of the impedance matching technique [2]. The dispersion of the MSFVW and MSBVW is calculated by numeric solving the Walker equation as well as with the use of the approximate dispersion relations.

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Th-PB004
FERRITE AS THE HOLOGRAPHIC MEDIUM FOR RECORD AND PROCESSING OF HIGH-FREQUENCY SIGNALS

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As is known, the polycrystalline ferrite give sunique possibilities for the long-term recording of phase - amplitude images of electromagnetic and ultrasonic pulse signals in a range from 1 to 30 MHz. The hologram playback is carried out as signals of the domain-acoustics echo (DAE). The devices based on this effect realize the correlation processing and controllable time delay of high-frequency pulse signals, and can represent itself as multi frequency ultrasonic emitters with the space scanning of the sonic polar pattern.

To fix the specific requirements to the electromagnetic and structural parameters of DAE materials we synthesized and studied series of ferrite samples with structures of spinels and garnets as well as with hexagonal structure. The DAE occurs only in materials with a high symmetry of a crystalline structure (spinels and garnets). The coercitivity must exceed 0.1 kA/m and saturation magnetization be more than 130 and 400 kA/m for garnet and spinel accordingly. The strong correlation of the DAE signal characteristics with the value of the crystal grain size D_a and degree of a structural homogeneity of the polycrystalline ferrites was determined. For the garnet samples the DAE signal increases with the grain size decreasing ($D_a \leq 10$ mkm). In all cases the porosity must be less of 1.5-2%. Precise thin boundaries of the crystallite are required.

Th-PB005

ULTRA SHORT MAGNETOSTATIC WAVE PULSE FORMATION

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A new way to form narrow microwave pulses from long input spin wave pulses has been developed. The narrowing is obtained for magnetostatic surface wave (MSSW) and backward volume wave (MSBVW) excitations when excited at high power levels. The frequency must be sufficiently low such that three magnon interactions are allowed.
A 10.2 μm thick yttrium iron garnet (YIG) film in a standard microstrip delay line structure was used in the experiments. For a carrier frequency below 3.3 GHz, one observes a pulse distortion in the form of the narrowing at the pulse leading edge which accentuates with power. One can achieve output pulses which are as narrow as 10 ns and 2 ns for the MSBVW and MSSW configurations, respectively. The input pulse can be arbitrarily long. For frequencies above 3.3 GHz, the increase in power produces a relatively broad initial pulse, typically 20 ns wide, which is followed by a transient decay to some nonzero background. There is no pulse narrowing. The pulse narrowing is attributed to Suhl first order parametric instability processes in which the pumped excitation splits into two approximately half-frequency magnons. Such splitting is allowed only when the position of the spin wave band is such that half frequency magnons are allowed. For low wave number MSBVW and MSSW excitations in YIG films, this is possible only below 3.3 GHz. The generation of these half frequency parametric magnons which accompany the pulse narrowing has been verified from microwave and Brillouin light scattering measurements.

Th-PB006

MICROWAVE PROPERTIES OF Ti^{4+}/Co^{2+} - SUBSTITUTED BaM FERRITES

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We have examined the microwave properties of hexagonal $BaFe_{12-x}\{Ti^{4+}Co^{2+}\}_xO_{19}$ ferrite at x=0.5; 0.8 and 1.1 in frequency range from 25 to 50 GHz using the tapered waveguide sections coupled by the tangentially magnetized ferrite samples placed in the electromagnet's gap. The amplitude-frequency response characteristic of the channel was investigated depending on the value of the magnetic field up to 22 kOe. Using the obtained results it was found that the uniaxial anisotropy field decreases from $H_A \approx 13$ kOe at x=0.5 to $H_A \approx 9$ kOe at x=1.1 with the inserted losses increase. The best result of use the experimental section with the sample having x=0.5 as a pass-band filter is the following: variation range of filter frequency 35-50 GHz, signal attenuation at central filtration frequency 5-10 dB, filtration bandwidth at 3 dB 700 – 1500 MHz, signal suppression beyond filtration band 20 – 30 dB.

Th-PB007

MAGNETOSTATIC WAVES SELF-ACTION EFFECTS UNDER CONCURRENT OF SELF-FOCUSING AND SELF-MODULATION

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Magnetostatic backward volume waves (BVMSW) self-action effects under concurrent of self-focusing and self-modulation are investigated in the framework of non-stationary 2D-nonlinear Shroedinger equation numerical solution. The parameters of BVMSW were found when square input impulse at some distance from the input antenna transforms into 2D – soliton or an impulse of new topological form with wave front dislocation – "torus". For continuous excitation the conditions were determined when self-modulation and self-focusing of BVMSW beam coexist and transform at some distance from input antenna in to spatial-temporal chaos. The stability of finding regimes with respect to dissipation and perturbations of initial conditions in the form of an additional periodical signal is also studied.

Th-PB008

MAGNETOELASTIC WAVES IN Ga- AND Sc-SUBSTITUTED YIG FILMS AND PLATES

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Magnetoelastic surface and volume waves propagation in Ga- and Sc- substituted YIG films and plates were studied both experimentally and theoretically. Magnetoelastic surface waves arising as a result of surface acoustic (SAW) Rayleigh and backward volume magnetostatic (MSBVW) waves resonant interaction were investigated at 116 MHz in epitaxial Ga- and Sc-YIG films with thickness of 30 μm tangentially magnetized in bias field $H_0 = 10...30$ Oe. The resonant interaction leads to attenuation of Rayleigh SAW ~ 20 dB/cm. Magnetoelastic volume waves arising as a result of MSBVW and Lambs modes of Ga- and Sc-:YIG/GGG waveguide structure were investigated at 800…1100 MHz in epitaxial Ga-,Sc-YIG films with thickness of 7μm tangentially magnetized in bias field $H_0 = 150...300$ Oe. All experimental data are in agreement with theoretical calculations of magnetoelastic waves propagation characteristics.

It was shown that the degeneracy of the cut-off frequency of BVMSW modes with different numbers is lifted by magnetoelastic interaction. As a result different BVMSW modes may interact with each other. It was also shown that conditions of so-called "strong magnetoelastic coupling" [1] can be fulfilled for resonance interaction of MSBVW and Lambs modes with phase velocity close to sound velocity in infinite medium.

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Th-PB009

ANGLE-RESOLVED PHOTOEMISSION IN ANTIFERROMAGNETIC CUPRATES

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Angle-resolved photoemission (ARPES) is considered to be a most powerful instrument to examine electronic structure and quasiparticle dispersion in parent and doped copper oxides including model systems like $Sr_2CuO_2Cl_2$. However, ARPES data and their analysis remain highly controversial. As a rule, conventional theoretical approach to ARPES data implies a number of rather strong simplifications, such as a single-band model, neglect the $\vec{q}$-dependence of dipole matrix element when photocurrent straightforwardly inspects the quasiparticle spectral function. For example, the low-energy part of the ARPES spectra in antiferromagnetic $Sr_2CuO_2Cl_2$ [1] is considered to be a manifestation of the well-isolated Zhang-Rice (ZR) singlet dispersion and explained in the framework of the $t-t'-t''-J$-model [2]. We show that these data could be consistently explained as a peculiar interplay of the *intensity dispersion* for two dispersionless valent states for the hole CuO_4^{5-}- center like ${}^1A_{1g}$ (ZR- singlet) and ${}^1E_u$ separated by ≈ 0.3 eV. Contrary to ZR-singlet, the latter represents the $b_{1g}e_u$ configuration with the purely oxygen e_u-hole. Occurrence namely of ${}^1E_u$ valent term is indicated by a nonzero photocurrent intensity at Γ point of Brillouin zone.

[1] B.O. Wells, Z.-X. Shen et. al., Phys. Rev. Lett., 74, 964, (1995).
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Th-PB010

SAMPLE PREPARATIONS AND MAGNETIC PROPERTIES OF Gd DOPED EuO THIN FILMS

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Magnetic semiconductor thin films of $Gd_XEu_{1-X}O$ ($0.005<x<0.05$) on quartz substrates were prepared using evaporation method in ultra high vacuum. The Curie temperature of a sample (x=0.045) increased up to 140K enhanced from 70K in EuO. The enhancements of Tc are caused by the additional d-f spin exchange interactions among the carriers on the conduction band and the lattice site spins. The resistivity for a sample (x=0.5%) in zero magnetic field slightly decreased in the higher temperature range above 75K and it rapidly decreased with decreasing temperatures in 75-25K. We found a large negative magnetoresistance of this sample more than 57% at 45K in 1.6T. These prepared samples showed the same magnetic and electrical properties as those of bulk Gd doped EuO. Now, we are investigating on the possibility of photo-induced magnetic phase transitions in local spin system composed of lattice site spins of 10^3 with several photo-induced carriers.

Th-PB011
INVERSION OF SHAPE OF DIPOLE SPIN WAVE SIGNAL

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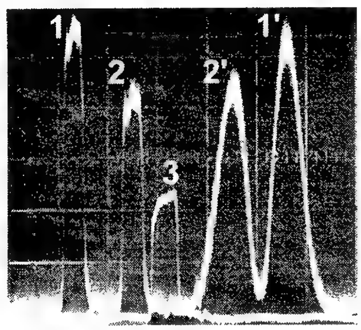
Inversion of the shape of the dipole spin wave microwave pulse signal has been realised for the first time in the experiment with backward volume magnetostatic waves (BVMSW) in the yttrium iron garnet (YIG) film. In the experiment the ac pump magnetic field of a 9448MHz frequency has been created by the open dielectric resonator with the length of 4 mm. This resonator was placed on the YIG film surface between two microstrip transducers. First transducer was used for sending the input BVMSW signal and receiving the amplified phase conjugated signal that has moved in reverse direction with respect to input one. The second transducer was used for the control of the transmitted signal and determination of a group velocity (2.21 cm/μs for a 4724 MHz carrier frequency, bias field of 1020 Oe and film thickness of 4.9 μm) and other BVMSW properties. Figure represents the oscillogram of inversion of the two pulse input signal. Here 1,2 - input signals, 1',2' - inverted signals, 3 - pump signal; time scale - 50 ns/div.



The analysis was performed on the base of theory reported early in [1]. Both shape and amplitude of inverted signals are accurately approximated by the theoretical calculations.

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Th-PB012
ARTIFICIAL MAGNETICS WITH DISORDERED STRUCTURE

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The composite non-magnetic materials, which behavior in alternating electromagnetic field is magnetic, are prospective to be used in microwave technique, for instance, as radioabsorbers. We have shown earlier that the medium on the base of spherical particles covered up by thin metal film is an artificial magnet. The approximation, which is based on Maxwell Garnett model, has been proposed for such a medium. This approximation deals with ordered positions of the inclusions in dielectric matrix. However, in real composite materials the chaotic distribution of inclusions usually takes place. The matter of the present work is to develop a theoretical model of such a material.

We have shown earlier that the Bruggeman approximation better corresponds to a chaotic structure. Following this approximation, the equations for the effective dielectric constant and for magnetic constant of medium are obtained. The comparison between the characteristics of ordered structures and chaotic ones is made. We have obtained for paramagnetics that the disordering leads to the notable shift of magnetic resonance to the low frequency range. The shape of resonance curve is changed and this change consists in the line broadening. The imaginary part of permeability at resonance is decreased. The components of complex electric constant are increased. As for diamagnetic, the influence of disordering on the permeability is weak concerning.

The approach proposed allows to investigate the similar structures which have an intermediate degree of ordering.

Th-PB013
FERROMAGNETIC RESONANCE IN METALLIC NANOWIRES

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A stripline structure using a nanoporous polymer membrane was developed in order to investigate the microwave properties of 3d metals. The cylindrical pores of the membrane were filled by Ni, Co or NiFe alloy; the synthesis was performed by electrodeposition according to the template method. The pore size and the pore density of the membranes were varied in the ranges 80 nm - 500 nm and 10^7-10^9 pores/cm^2 respectively. Ferromagnetic resonance investigations were then carried out: such a study becomes possible on ferromagnetic metals if the diameter of the wires is smaller than the skin depth at the considered frequencies. Measurements were performed at frequencies ranging from 100 MHz to 40 GHz and under static magnetic fields up to 5.6 kOe applied along the wires axis.
Resonance phenomena have been observed in the magnitude of the complex transmission coefficient for all the samples studied. The resonance frequencies strongly depend on the nature of the material and on the applied static magnetic field; due to strong demagnetising effects in the ferromagnetic wires, the gyromagnetic resonance occurs at microwave frequencies even in absence of any DC magnetic field. An interesting point comes from the large frequency band in which the resonance occurs : it can vary from 11 GHz for Ni at zero field up to 38 GHz for Co at 5.6 kOe. From a theoretical point of view, results are consistent with those expected for a ferromagnetic resonance (FMR) experiment and the observed behaviours are analysed in the framework of the classical FMR theory [1].

[1] G.Goglio, S.Pignard, A.Radulescu, L.Piraux, I.Hyunen, D.Van Hoenacker, A.Van der Vorst Appl. Phys. Lett. **75**(12) (1999)

Th-PB014
APPLICATION OF THE BETHE-PEIERLS-WEISS METHOD TO YTTRIUM IRON GARNET CONTAINING Y^{3+} IMPURITY

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The presence of Y^{3+} impurity in a-sublattice (yttrium antisite defect) of YIG causes appearing of the rich satellite structure in the ^{57}Fe NMR spectrum. Different satellites correspond to different, magnetically inequivalent, (Fe^{3+}- impurity) pairs. Temperature dependence of the resonance frequencies of the NMR lines is determined by the exchange interaction of Fe^{3+} ions and by the dynamics of the system of electron spins. Thus the temperature dependence of the satellite frequencies reflects the modification of the exchange interaction and of the electron spin dynamics due to the presence of Y^{3+} impurity.
Theoretical description of the temperature behavior of the main lines and satellites has been carried out in the frame of model based on the Bethe-Peierls-Weiss approximation. Temperature dependence curves for different satellites were calculated in the temperature region 4.2K-T_c. Results were compared and supported by experiment: NMR spectra of ^{57}Fe in YIG containing Y^{3+}(a) impurity in the temperature region 4.2K-360K.

Th-PB015
SIZE RESONANCE OF MAGNETIC POLARITONS IN A PLATE OF $FeBO_3$

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The intensive modes of microwave inhomogeneous oscillations of magnetization - magnetic polaritons (MP) on the frequency of 25-75 GHz were observed in massive, free from an external pressure plates of iron borate at 77 K. Samples of $FeBO_3$ were synthesized from the gas-phase on the method of [1]. Size resonance of MP is investigated. The strong dispersion of the phase velocity for MP at the intersection of their spectrum with the line of uniformed antiferromagnetic resonance of the low branch of electron spin oscillations was observed. The discussion of experimental results using main elements of the theory [2] is executed.

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Th-PB016
POSSIBILITY OF LARGE SOLITON AMPLIFICATION BY LOCALIZED NONSTATIONARY PARAMETRIC PUMPING

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Amplification of microwave magnetic envelope solitons in yttrium iron garnet (YIG) films by localized electromagnetic pumping have been investigated both experimentally and theoretically. Experiment was performed using strong localized and strong nonstationary pumping; the maximal pump power $P_{p\ max}$=5 W was several times greater than threshold of the parametric excitation of the signal waves $P_{p\ th}$=1.1 W. The maximal soliton gain K reached 17 dB and was restricted not by limiting of pump power, but by appearance of second soliton, i.e. by transition to multisoliton regime of wave propagation. In the case of ideal stationary amplifier such transition take place at significantly lower soliton gain K=6 dB.
For the theoretical explanation of described phenomena we have solved the general problem of parametric interaction of counter-propagated waves with spatially localized pulse pumping. Under our experimental condition output signal can be several times shorter than input one. Such signal compression considerably increases the threshold of second soliton formation and allows us to amplify single-soliton signal up to more than 6 dB. It was found that maximum single-soliton amplification coefficient K_{max}=20 lg($2\tau_s/\tau'_s$) dB, where τ'_s is the signal pulse duration at the output of amplifier.
Linear signal compression was also observed in our experiments. Both effects are in qualitative coordination with theoretically predicted ones.

Th-PB017

METHODS OF THE CREATION,SWITCHING AND RECTIFICATION OF A SURFACE PHONON POLARITONS OF INSULATOR AT ITS BOUNDARY WITH A METAL

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The existence of a surface phonon polaritons in an insulator at its boundary with an ideal metal or superconductor in a static electric or magnetic field is predicted. These surface polaritons may be radiant and be excited by a direct interaction with electromagnetic waves. The frequency range in which polaritons exist is substantially different for opposite orientations of each field, so that a change in the direction of the field signifies "switching on" or "switching off" of surface polaritons with a fixed frequency.In the presence of a magnetic fild surface polaritons of the given optical or IR frequency propagate only in one direction with respect to magnetic field, it is the effect of the rectification of phonon polaritons. In crossed electric and magnetic fields surface polariton modes are strongly depended not only on directions of the fields but on the relations of their values (H/E). The frequency regions of the switching, rectification and of the existence of a radiant modes can be regulate by the change of the directions and values of external fields.

Th-PB018

LOCAL MAGNETIC FIELDS IN FERROELECTRIC-MAGNETIC CERAMICS $AFeO_3$ (A = Bi, Sr)

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The hyperfine fields at the ^{57}Fe-sites and their temperature dependence (4.2 – 300K) have been measured by the nuclear magnetic resonance (NMR) and Mössbauer spectroscopy (MS) in $AFeO_3$ (A=Bi, Sr). The ^{57}Fe NMR spectra are an evidence for the incommensurate cycloidal magnetic structure in $BiFeO_3$. The long-period anharmonic cycloidal magnetic structure has been restored from the NMR spectrum in $BiFeO_3$. Influence of oxygen composion on the magnetic state of the Fe atoms in $SrFeO_{3-x}$ has been studied by NMR and MS. The temperatures of the magnetic transition and the values of the critical exponent were also determined for the $SrFeO_{3-x}$ perovskites.

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Th-PB019

ULTRA COLD NEUTRON SCATTERING BY OUTER SURFACE OF FERROMAGNETIC SEMICONDUCTOR WITH NON-EQUILIBRIUM MAGNETIZATION GRATING

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In this paper the ultra cold neutrons scattering by the outer surface of the ferromagnetic semiconductor (FMSC) with a grating of non-equilibrium magnetization, produced by coherent laser beams, was investigated. The ultra cold neutron reflection coefficient by outer surface of FMSC with the grating of non-equilibrium magnetization near the Bragg resonance, was calculated. It is shown that the presence of the non-equilibrium magnetization grating essentially exchange the magnetic properties of FMSC. At the value of neutron wave vector $\vec{g}$ inside the FMSC near to the condition of the Bragg resonance, the ultra cold neutron reflection coefficient essentially differ from its value in a homogeneous FMSC event a small modulation of the non-equilibrium magnetization. The external constant electric field $\vec{F}_0$ essentially influence on the value of neutron reflection coefficient. It is shown that the appear the possibilities to study the magnetic properties of FMSC using by ultra could neutron beams and operating the ultra could neutron beams by the grating of non-equilibrium magnetization, produced by coherent light beams.

Th-PB020

COMBINED EFFECTS OF MR AND PHR IN NiO/NiFe BILAYER

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In this work, we present the enhancement of magnetoresistance (MR) ratio using biaxial currents in bilayer NiO(30 nm)/NiFe(30 nm), by introducing the combined effects of MR and Planar Hall Resistance (PHR). A sensing current I_x of 1 mA was applied in x-direction and an auxiliary current I_y was applied in the y-direction, where the direction of exchange field in the cross shaped sample was regarded as y-direction. The anisotropic resistance under magnetic field is governed by the vector equation for Ohm's law[1].
When the biaxial currents $I=(I_x, I_y)$ are simultaneously introduced in the sample, the components of resistance tensor for x-y plane are given as functions of resistivity and currents I_x, I_y. The voltage measured in x-direction is given as a sum of $R_{xx}I_x$ and $R_{xy}I_y$, and the offset voltage V_o due to intrinsic resistance R_{xx}, restricting the MR rario of $\Delta R/R_{xx}$, can be reduced by adjusting I_y. Using this method, apparent MR ratio, $\Delta V/V_o$ is enhanced over 100 %, which has an advantage over the reported type MR bridge elements compensating the offset voltage.

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Th-PB021

AMORPHOUS MAGNETIC BIMETAL RIBBONS

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Amorphous bimetal ribbons consisting of the nonmagnetostrictive ($Co_{68.25}Fe_{4.5}Si_{12.25}B_{15}$) and positive magnetostrictive ($Fe_{78}B_{13}Si_9$) or negative magnetostrictive ($Co_{72.5}Si_{12.5}B_{15}$) components were prepared by melt-spinning method using two-chamber crucible. These amorphous bimetal ribbons are very sensitive to any change in temperature and magnetic applied field because of the different magnetostriction constants and thermal expansion coefficients of the components. By applying an external magnetic field, we obtained different magnetic deflections of the amorphous bimetal ribbons depending on their composition, the value and the sign of the magnetostriction constants of the components, the saturation magnetostriction and to the thickness of the component ribbons and of the bimetal ribbons, whose values ranging from 2.5 μm/Oe to 5 μm/Oe for the $Fe_{78}B_{13}Si_9$ / $Co_{72.5}Si_{12.5}B_{15}$ and $Fe_{78}B_{13}Si_9$ / $Co_{68.25}Fe_{4.5}Si_{12.25}B_{15}$ amorphous bimetal ribbons, respectively. The values measured for the thermal deflection are between 10 μm/K for the amorphous bimetal ribbons consisting of the nonmagnetostrictive and Fe-rich components and 25 μm/K for the $Fe_{78}B_{13}Si_9$ / $Co_{72.5}Si_{12.5}B_{15}$ amorphous bimetal ribbons. These amorphous bimetal ribbons obtained by melt-spinning method, which presents magnetic and thermal deflections, will be used as field and temperature sensors and transducers for various electric and electronic applications.

Th-PB022

Withdrawn

Th-PB023

THE ELECTRICAL RESISTANCE BINARY DILUTE CHROMIUM ALLOYS WITH 3d-ELEMENTS.

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The electrical resistance has been studied as a function of temperature and pressure in binary dilute chromium alloys with 3d-elements. The appearance of the spin density wave (SDW) is marked by anomalies in the electrical resistance below the Neel temperature T_N. In accord with the nesting band model [1-3], T_N and other properties strongly dependence with electron to atom concentration of alloys. In the SDW (incommensurate and commensurate) magnetic structures anomalous behavior of electrical resistance versus temperature is the consequence of annihilation electron and hole parts of Fermi surface and the energy gap formation. The fitting parameters such as the energy gap and the number of electrons involved in the process of the SDW formation have been determined.

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Th-PB024

TWO-COMPONENT FERROZONDE SENSOR FOR MEASUREMENTS OF THE FERROMAGNETIC PHASES IN AUSTENITE STEELS

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The control of stability of the magnetic state in austenic steels is carried out using different methods and instruments. One of them is the utilization of ferritometers, the main element of which is the attachable differential magnetomodulational transducer (ferrozonde). Meanwhile the available constructions of the transducers, alongside with the advantages, have some properties that are limiting the possibilities of the method, thus narrowing the nomenclature of the products and materials under control and are not ensuring the required accuracy of measurements. The new construction of the transducer was developed in order to improve the abovementioned disadvantages.
The transducer is made of the nonmagnetic body in which the permanent magnet is placed for local magnetization of the surface area of the product under control. The magnetosensive elements of the transducers are placed at the opposite sides of the magnet in the plane of its neutral section. The magnetosensive elements of the transducers are operating in the gradient and magnetic field measurement modes [1].

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Th-PB025

Withdrawn

Th-PB026

MAGNETIC AND MAGNETOOPTICAL PROPERTIES OF Pr-Bi- AND Sc-Bi-SUBSTITUTED LUTETIUM IRON GARNET FILMS

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The epitaxial iron garnet film of $(LuPrBi)_3(FeAl)_5O_{12}$ and $(LuBi)_3(FeAlSc)_5O_{12}$ systems were grown on (111) oriented GGG (gadolinium gallium garnet) substrates up to 3" in diameter by LPE technique. Compositions and growth conditions were varied to study a change of magnetic anisotropy and magnetooptical activity in respect of application in magnetooptical visualization of magnetic irregularities. But the lattice parameter was conserved to have a possibility to use the commercially available substrates of GGG. The magnetic and magnetooptical properties of obtained films were investigated in the temperature range 80–400 K and discussed basing on the analysis of their content.
All grown films demonstrated a magnetic anisotropy close to the in-plane type in a whole temperature range. At the same time the uniaxial component of magnetic anisotropy has an opposite sign in two investigated systems. Moreover, a strong cubic anisotropy contribution in Pr-substituted films results in essential distortion of the normal magnetization curves at temperatures less than 100 K. A possibility to enhance the magnetooptical activity of the films with given magnetic properties (a type of magnetic anisotropy and saturation field in normal direction) is discussed.

Th-PB027
MAGNETOSTRICTIVE CANTILEVER BIMORPHS

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The deflection of a cantilever coated with magnetostrictive material can be utilised in novel microsensors and actuators. It can also be used to measure the magnetoelastic properties of the coating. A brief review on the existing literature will be given. Existing analytical models predicting the bending of a magnetostrictive bimorph all assume negligible film to substrate thickness. For micromachined cantilevers it is necessary to consider comparable thicknesses. We present a new theory based on total energy minimisation. Our analysis agrees with previously carried out finite-element analysis and reduces to the known solution in the thin-film limit. It presents a first basis for the optimisation of cantilever response and will have many applications in the emerging field of piezomagnetic micromechanical devices.

Th-PB028
MAGNETIC PHASE DIAGRAMS OF THE SYSTEMS ON THE BASE OF Cr WITH d-TRANSITION METALS AND PROPERTIES OF THESE ALLOYS

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Perculiarities of magnetic transitions are studied and MPD of binary system Cr-based alloys with d-transition metals [1,2] are built. Triple points are revealed at low concentrations of metals of groups VII and VIII of periodic table [3]. The following phases coexist at this point: i) incommensurable SDW, like in pure Cr, ii) commensurable SDW and iii) paramagnetic phases. Characteristic MPD of ternary systems are studied: Cr-Mn-Me (Me=V, Ta, Fe, Co, Ni) [4,5]. Practically useful alloys having invar [6,7] and resistive [8] properties are observed only at phase concentration transition 'paramagnetic ↔ commensurable SDW' (I↔II tipe) on MPD of ternary systems.

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Th-PB029

GLASS - LIKE PROPERTIES OF THE METALLOORGANIC NITROZO-β-NAPHTHOL WITH IRON (II) COMPLEX.

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Static and dynamic aspects of magnetic behavior of the metalloorganic nitrozo-β-naphthol with iron (II) complex {$Na[Fe(C_{10}H_6NO_2)_3]$} have been established by analysing the dependencies of ac susceptibility (χ_{ac}) and dc magnetization (M_{dc}) on temperature, frequency and magnetic field. These dependencies have been measured over the temperature range 1.5-200 K, in external magnetic field up to 90 kOe and over the frequency range from 95 to 2000 Hz. The experimental data indicate the absence of magnetic long range order in this complex. The magnetization reaches a value close to saturation at 1.5 K in the field as high as 90 kOe. At low temperatures, the following peculiarities of magnetic behavior, characteristic of the glasses, have been found in complex studied: cusp-like anomalies in the ac susceptibility and in the ZFC magnetization at T_{cusp}=17 K, a frequency dependence of the T_{cusp} temperature, a remanence and a time-dependent relaxation of ZFC magnetization. Attempts have been made to compare the χ_{ac} and M_{dc} anomalies in this complex with those of other magnetic systems. Many similarities with both spin glasses and superparamagnets were found. Although superparamagnetic behavior should not be completely ruled out as an explanation of the freezing phenomena in our complex, the analysis of experimental results strongly suggests that the spin-glass-like behavior is the most consistent explanation.

Th-PB030

SYNTHESIS AND MAGNETIC PROPERTIES OF CHIRAL MOLECULE-BASED MAGNETS

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The molecule-based materials with special magnetic, magneto-optical and electrical properties are one of the major challenges in the last few years [1]. We have developed a strategy of using π-conjugated high-spin oligonitroxide radicals which can be used as bridging ligands for paramagnetic transition metal ions in order to assemble and align on a macroscopic scale the 3d-spins [2].
Here we introduce a series of chiral magnets made up of chiral organic triplet bisaminoxyl radicals, chiral doublet nitronyl nitroxide radicals or chiral diamines and transition metal ions. Magnetic properties and crystal structures of some new chiral complexes will be discussed:
i) A 1-D ferrimagnetic-chain complex [**1**•Mn(II)(hfac)$_2$]$_n$, **1** is 1,3-bis(*N-tert*-butylamino-*N*-oxyl)5-{1'-methyl-1-((*S*)-2''-methylbutoxy)ethyl}benzene and (hfac) is hexafluoroacetyl-acetonato, which orders antiferromagnetically at 5.4 K and shows a metamagnetic behavior.
ii) A 1-D ferrimagnetic-chain complex [**2**•Mn(II)(hfac)$_2$]$_n$, where **2** is 2-{4'-((*S*)-2''-methylbutoxy)phenyl}-4,4,5,5-tetramethylimidazoline-1-oxyl-3-oxide.
iii) A series of 3-D ferrimagnets, analogues of 'Prussian blue', based on Mn(II) and Cr(III) ions and bridged by various chiral ligands, with T_C reaching up to 108 K.
[1] Kahn O., Ed. // Magnetism: A Supramolecular Function, Kluwer Acad. Publ., (1995), 484 p.
[2] Iwamura H., Inoue K. and Koga N. // New J. Chem. 22, (1998), p. 201.

Th-PB031

THE STUDY OF THE ABSORPTION COEFFICIENT OF MAGNETIC FLUID IN THE INFRARED REGION

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Magneto-optical effect in the magnetic fluids based on mineral oil, damping oil, paraffin and kerosene with different volume concentration of magnetic particles in infrared region from 3200 to 5000 cm $^{-1}$ has been studied. The wavenumber dependences of the absorption coefficient on the magnetic field H and angle Θ (Θ is the angle between the electric vector of incident light and the applied magnetic field) have been measured. The experimental data of magneto-optical effect proved existence of universal angle $\Theta_c = 54.73^0$ for which the change of absorption coefficient is wavenumber and magnetic field independent for the magnetic fluids studied in agreement with theoretical prediction [1].

[1] Kopčanský P., Macko D., Horváth D., Kašparková M. and Tima T. // J. Magn. Magn. Mater., 122, (1993), p.150.

Th-PB032

THE INFLUENCE OF THE MAGNETIC FIELD ON THE ELASTIC AND VISCOSITY PROPERTIES OF MAGNETOELASTICS.

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The new composite magnetosensitive materials were prepared introducing iron and magnetite particles in polymer matrix based on siloxane caoutchouk [1].
These materials called magnetoelastics are characterized by large value of magnetodeformational effect, which consist in sample shape and size change in magnetic field.
Structural, magnetic, elastic and viscosity properties of these materials are considered. The special attention is directed to the effect of the influence of magnetic field on the elastic characteristics of these materials. In particular, we found that the Youngs modulus of such materials considerably increases in magnetic field.
Also it was found that magnetic field changes viscosity properties of magnetoelastics. For that we considered changes character of natural oscilations of pendulum, where magnetoelastic was used as an elastic element.
Analysis of the influence of magnetic field on the character of oscillation was carried out on the basis of the Kelvin model.

[1] Nikitin L.V., Levina E.F., Stepanov G.V., Mironova L.S. //The abstracts of reports of XVI International school-seminar "The new microelectronics materials", Moscow, 23-26 June 1998, p. 389.

Th-PB033
COLLOIDAL SOLUTIONS OF FERROMAGNETS

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The colloidal solutions of ferromagnets have application for preparation of magnetic fluids and toners for copying apparatus. Synthesis of dispersed ferromagnets includes the two main stages : a) preparation of primary particles with magnetic properties and b) formation of magnetic dispersion which is the assembly of clusters.
Formation of primary magnetic particles is carried out by codeposition of metal hydroxides from its salt solution and potassium hydrate. At the initial stage of synthesis the ferromagnetic substances have the monodomain structure. For its preservation the special dopes of electrolytes may be introduce in reaction mixture.
The regulation of clusters size and form is accomplished with the help of surface modificators of magnetic particles. As modificators of surface the mordant and direct dyes may be used [1].
Development technology gives possibility to produce the colloidal solution of ferromagnets with controlled magnetic properties and dispersed assembly of clusters.

[1]. M.S.Tsvetkov, I.Y.Maleev, I.E.Opaynych. Preparation method of dispersed ferrite for magneto-sensitive developer of latent electronography image . / Patent No 23059A (Ukraine). Publ. 30.06.1998, B.I. N 3.

Th-PB034
THE DETERMINATION OF PARTICLE SIZE DISTRIBUTION FUNCTION OF MAGNETIC FLUIDS BY MEANS OF FORCED RAYLEIGH SCATTERING METHOD

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The Forced Rayleigh scattering method (the interference field of two intensive laser beams in the thin film of magnetic fluid) was used to create a periodical structure of density of magnetic particles. This creation is caused by thermodiffusion effect known as Soret effect. The obtained structures of fine magnetic particles were indicated as a self diffraction of used primary laser beams. The relaxation phenomena after switching off laser interference field were discussed in terms of spectrum of relaxation times. This spectrum is proportional to hydrodynamic particle size distribution function of fine magnetic particles. The relaxation of optical grating in studied petroleum based magnetic fluid consists of two well defined channels i.e.decay through single particles and small aggregates respectively.

Th-PB035

THE MAGNETIC FREDERICKSZ TRANSITION IN COMPLEX SYSTEMS CONSISTED OF LIQUID CRYSTAL AND FINE MAGNETIC PARTICLES

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The stable ferronematics and ferrosmectics (combination of liquid crystals with fine magnetic particles) were prepared for 8CB liquid crystal and fine magnetic particles 11 nm in diameter. The structural transitions i.e. magnetic and electric Fredericksz transitions were indicated by means of dielectric and conductivity measurements. The experimental results i.e. the proof of initial condition $\mathbf{n}_0 \perp \mathbf{m}_0$ ($\mathbf{n}_0$ is director of LC molecules and $\mathbf{m}_0$ is magnetic moment of particles) and the increase of the threshold field of magnetic Fredericksz transition vs volume concentration of magnetic particles are in qualitative agreement with the Burylov and Raikher theory of thermotropic ferronematics [1].

[1] Burylov S.V. and Raikher Yu.L. // J. Magn. Magn. Mater., 122, (1993), p.62.

Th-PB036

INFLUENCE OF PARTICLE CONCENTRATION ON FERROFLUIDS MICROSTRUCTURE STUDIED BY SANS

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It is known that the stability and properties of magnetic colloidal solutions are considerably due to the degree of surfactant adsorbtion at the ferrophase surface. Also the micro-behavior of the surfactant molecules adsorbed at the surface of the particles is not yet completely understood [1,2].
The purpose of this work is to investigate the changes of the surfactant layer structure due to the variation of the colloidal particles concentration [3] by the SANS method [4]. It is interesting the result which was obtained from these measurements, that the thickness of surfactant shell is increasing with the decrease of the particle concentration, the same time the degree of the solvent penetration in the surfactant shell is constant.

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Th-PB037

NEW DATA ON HIGH GRADIENT MAGNETIC SEPARATION IN ANGULAR STEPS

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Using a rotating HGMS ordered matrix in a quasitransversal configuration experiments have been performed to study the dependence of the captured mass m_s on the angle α between the direction of the applied field H_0 and the ferromagnetic wires. The ordered dependence of m_S on α registered experimentally reveals the possibility to successively separate a granular mixture by an adequate choice of the inclination angles without modifying the applied field H_0 or the average flow velocity v_a. Relationships were derived connecting the magnetic susceptibilities of the mixture components with the inclination angle α in order to accomplish such a separation in angular steps [1].
Also, a new benefit of an ordered HGMS matrix, made up of parallel ferromagnetic wires is presented. One shows the magnetic force F_m depends on α, the angle between the wires of the matrix and the applied magnetic field H_0.There is a relation between the tilting angles and the magnetic susceptibilities of the particles pulled out from the mixture. This relation proves the practical possibility of separating a complex mixture only by choosing adequate tilting angles; the method is named separation in angular steps [2]. Finally one shows two applications based on this principle: a separator which extracts successively and another one which extracts concomitantly different magnetic fractions from a granular mixture.

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[2] Gh.Iacob and N.Rezlescu, Powder Technology **97** (1998) p.233-236.

Th-PB038

DEVELOPMENT OF ELECTROMAGNETIC ROLL SEPARATOR FOR DRY SEPARATION OF SLAGS

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On the basis of the analysis of electromagnetic roll separator modern constructions for separation weak magnetic materials the roll separator construction with a C-figurative magnetic circuit is developed. The working area of improved separator is arranged by roll with trapezoidal bulges corresponding to hollows on poles.
Using a finite element method, the numerical modeling of a magnetic field in a working area between roll and pole is carried out. In result the dependences of reduced extracting force $(HgradH)_M$, created in an middle point between two roll bulges, from main geometrical parameters of a working area are obtained. These dependences allow to choose the most effective geometry of roll.
On the basis of the analysis of magnetic fluxes distribution in the magnetic system of separator the local magnetic fluxes are selected, for which the magnetic permeances are defined. Using a known lumped parameter method, the equivalent circuit of separator magnetic system is developed. The numerical computation technique of a magnetic circuit of given construction separator by a quadrosections method is worked out.
The results of numerical researches are checked and are specified on the basis of physical modeling. The guidelines on creation of more rational construction are worked out, the new construction roll separator for dump slags of highcarbon ferrochrome production is offered.

Th-PB039
HANDLING OF FOODSTUFF BY MAGNETIC IMPULSES

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The urgency of realization of experiments on development of unthermal methods of extension of term of storage of food is shown. The virtues of application of magnetic impulses for handling of food are analysed. The technology of extension of term of storage of liquid food packed in container is developed on base of action of impulse magnetic field. The optimum conditions of realization of "cold" pasterization process of bottled beer are defined. The conditions allow to prolong the term of storage of beer under condition of preservation of physical, chemical and other properties.

Th-PB040
GEOMETRY OF STATIONARY FLOWS OF LIQUID IN VICINITY OF THE HIGH GRADIENT FERROMAGNETIC PACKING IN CONSTANT EXTERNAL MAGNETIC FIELD

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Nowadays the high gradient ferromagnetic packings are widely used for filtration and separation in magnetic filters. The stationary flows of liquid are found out in vicinity of high gradient ferromagnetic packing of the magnetic filter in constant external magnetic field in initially motionless liquid. The geometry of flows was studied for different sizes of the packings on large distances from the packing in the shape of needle. The influence of value of the constant external magnetic field on geometry of flows of liquid was investigated. It was shown that the geometry of flows of liquid depends on the size of the packing. The results of the work can be used for designing magnetic filters and creation of the directed flows of liquid.

Th-PB041

ALLOWANCE FOR SPIN CORRELATIONS IN AN ALLOY-TYPE APPROXIMATION FOR THE HUBBARD MODEL

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In some approaches for studying the Hubbard model one had used successfully the "alloy-type" analogy between the motion of an electron over the lattice sites, occupied by other electrons with opposite spins, and the motion of the electron in a disordered binary alloy. Using the same ideas, we propose the method for investigation the magnetic phase diagram of the Hubbard model. One can simple show that the direct use of the well known coherent potential approximation does not allow to obtain the magnetic ordered state when the number of filling of electrons $n<1$. Since there are two time parameters $\tau_c \sim \nabla/E_F$ and $\tau_s \sim \nabla/(k_B T_c)$ responsible for the charge and spin density fluctuations and $\tau_s > \tau_c$, we consider the motion of an electron (with a fixed spin) over the lattice like the motion of an electron in a "binary alloy" with the spatial correlations [i.e. with the short-range order (SRO)] which are determined by the spin correlation functions. Basing on the method for calculation the Green's functions for disordered alloys with SRO [1], we minimize the ground state energy over the magnetization m and intrinsic SRO parameters $\alpha\uparrow$ and $\alpha\downarrow$. The difficulties are to solve self-consistently the integral equations for the self-energy. In order to simplify the calculations the simple case of an infinity space dimension is considered. We compare the obtained results with the known ones for the Hubbard model and define the limits of validity of our method.

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Th-PB042

SPIN-POLARIZED RELATIVISTIC ELECTRONIC STRUCTURE OF BERKELIUM

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Electronic structure calculations based on density functional theory of the ground state of ferromagnetic berkelium with fcc structure are performed by a self-consistent first-principles fully relativistic spin-polarized linear muffin-tin orbital method (SpRLMTO) [1]. The self-consistent band structure and calculated spin and orbital magnetic moments are compared with previous calculations. An analysis of an accuracy of various spin-polarized approaches is done.

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Th-PB043

STUDY OF THE CRYSTAL FIELD AND EXCHANGE INTERACTIONS IN SINGLE CRYSTAL HYDRIDE $HoFe_{11}TiH_{1-\delta}$

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The single crystal $HoFe_{11}Ti$ and its hydride with tetragonal $ThMn_{12}$-type structure were obtained. Magnetic torque measurements have been made on $HoFe_{11}TiH_X$ (x=0.1) single crystals in the temperature range 77-700K and magnetic fields up to 1.3 Tesla. Magnetization measurement along the main symmetry direction of the tetragonal structure have been performed on $RFe_{11}TiH_x$ (x=0.1) single crystals at applied high magnetic fields up to 14 Tesla in temperature range from 4.2K to 300K. The easy magnetisation direction of $HoFe_{11}Ti$ single crystal was found to be coinciding with the *c* axis in the whole investigated temperature range. Our results for $HoFe_{11}Ti$ agree well with data obtained earlier [1].
Interstitial H atoms occupy sites adjacent to the rare earth, creating a crystal field that reflects the new local symmetry. Spin reorientation transition appears at T_{SR}=140K after hydrogenation. The magnetic behavior has been explained using a mean-field model for the exchange interaction and a single-ion model for the crystal electric field interaction. A set of CEF parameters and mean exchange field have been obtained for $HoFe_{11}TiH_{1-\delta}$ single crystal.
The work has been supported by RFBR Grant N99-02-17821.

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Th-PB044

MAGNETIC PROPERTIES OF UNi_2Si_2 SINGLE CRYSTAL

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The tetragonal UNi_2Si_2 exhibits three different AF phases in zero magnetic field below T_N = 125 K. In all of them the U moment is parallel to the *c*-axis, forming ferromagnetic basal planes. Between T_N and 108 K the incommensurate AF1 phase with $\boldsymbol{q} = (0, 0, q_z)$ is established ($q_z \sim 0.74$). The phase AF2, between 108 K and 40 K, is of the AF-I type with $\boldsymbol{q} = (0, 0, 1)$ and the ground-state phase AF3 is the uncompensated squared-up AF structure with the (+ + -) stacking of basal planes along the *c*-axis ($\boldsymbol{q} = (0, 0, 2/3)$). Both 108 K and 40 K transitions are of the first order. The neutron scattering study of UNi_2Si_2 single crystal in magnetic fields up to 15 T shows a complex magnetic phase diagram. The 108 K phase boundary splits above 3 T and the AF2 phase disappears above 3.8 T. The T_N remains unchanged up to 15 T and the AF1 phase is getting narrower in high magnetic field, vanishing above 14 T. Only the AF3 phase exists up to T_N in higher fields. Strong field and temperature dependence of the q_z were observed in the AF1 phase, it shows steep decrease with applied field at the AF1-AF3 boundary.
The electronic structure and related properties (minimal lattice constants, *c*/*a* ratio, minimal value of z_{Si}, bulk modulus, spin and orbital magnetic moments) were calculated using FLAPW method based on density functional theory. The calculated ground state properties are in reasonable agreement with the experimental data available. The total magnetic moment consists of large spin and orbital components which and from our calculations follows the different pressure dependence of the particular component of the total moment.

Th-PB045

THE BEHAVIOR OF THE MAGNETIC SUSCEPTIBILITY AT THE PREMARTENSITIC TRANSITION IN Ni_2MnGa

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A lot of attention has been paid to the investigation of shape memory ferromagnetic Ni-Mn-Ga alloys. One of the fascinating feature of these alloys transforming martensitically at T< 300 K is the occurrence of the condensation of 1/3<110>TA_2 soft phonon mode preceding the martensitic transformation. In particular this premartensitic transformation is accompanied by the minimum of the real part of the initial complex magnetic susceptibility, χ, concurrently with the maximum of the imaginative part of χ and maximum of the mechanical internal friction.
In present work the behavior of χ–minimum for the near stoichiometric Ni_2MnGa compound has been studied by the induction method as a function of the different factors and variables. It was shown the minimum depth depends on the orientation of the crystallographic axes with regard to the applied measuring field. The increasing of the magnetic field frequency caused the decrease of anomaly magnitude . The results are discussed by the dynamics of the magnetic domain boundaries interacting with the micromodulated lattice of the premartensitic phase.

Th-PB046

EFFECT OF FREQUENCY AND DC CURRENT ON AC-BIASED ASYMMETRICAL MAGNETO-IMPEDANCE IN WIRES.

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Recently, a new asymmetrical giant magneto–impedance (AGMI) which utilises a high frequency bias field has been realised in a Co-based amorphous wire with a circumferential anisotropy . At certain conditions, the voltage V_w measured across the wire subjected to an ac current and an ac axial field h_b (of the same frequency, f) exhibits a strong asymmetry with respect to the axial dc magnetic field H_{ex} (sensed field). This paper is concerned with a strong sensitivity of AGMI to the frequency of excitation f and the dc current I_b applied to the wire, which effect on the linearity and the magnitude of the voltage output in a sensor circuit based on the AGMI elements.
The impedance measurements have been made in the frequency range of 0.01 – 150 MHz with Hewlett-Packard 2-channel Network/Spectrum Analyser. In the presence of h_b, the voltage is determined by the combination of the diagonal ζ_{zz} and off-diagonal $\zeta_{z\varphi}$ components of the impedance tensor. For a wire with a circumferential anisotropy, the parameter $\zeta_{z\varphi}$ is noticeable only if the dc current is applied, reaching a maximum for I sufficient to eliminate the circular domain structure completely. $\zeta_{z\varphi}$ also grows with frequency and becomes similar in magnitude to ζ_{zz} at $f \approx 1$ MHz. At such conditions, the voltage V exhibits a considerable asymmetry with respect to H_{ex}. A near-linear voltage output ±4 mV within the field interval ±5 Oe has been obtained using two oppositely biased AGMI at f=8 MHz and I =100 mA/m.

Th-PB047

ATOMIC MIGRATION IN $Co_{0.9}Mn_{0.1}Fe_2O_4$ PREPARED BY A SOL-GEL METHOD

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$Co_{0.9}Mn_{0.1}Fe_2O_4$ prepared by a sol-gel method has been studies by Mössbauer spectroscopy and X-ray diffraction. The crystal structure is found to have a cubic spinel structure with the lattice constant of $a_0 = 8.384 \pm 0.005$ Å. The iron ions at both *A* (tetrahedral) and *B* (octahedral) sites are found to be in ferric high-spin states. Its Néel temperature T_N is found to be 850 ± 2 K. Debye temperatures for *A* and *B* sites are found to be $\Theta_A = 757 \pm 5$ K and $\Theta_B = 282 \pm 5$ K, respectively. Atomic migration from the *A* to the *B* sites starts at about 400 K and increases rapidly with increasesing temperature to such a degree that 52 % of the ferric ions at the *A* sites have moved over to the *B* sites at 700 K.

Th-PB048

SPECIAL FEATURES OF CRYSTALLINE STRUCTURE AND MAGNETIC PROPERTIES OF HIGH PERMEABILITY GRAIN ORIENTED 3%Si STEELS

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Magnetic properties of grain oriented electrical steels are strongly dependent on the sharpness of {110}<001> orientation of the secondary recrystallized grains. Grain size and texture of primary recrystallization strongly influence secondary recrystallization evolution and magnetic properties of the material. The interrelation between micro- structure, texture and magnetic properties of 3%Si steels at different recrystallization stages has been studied in the present work. Texture evolution during recrystallization was studied with the help of EBSD (Electron Back Scattered Diffraction) using SEM.

It has been shown that large primary grains (over than 35μm) are closer to the {110}<001> orientation than smaller grains. Small grains (less than 25μm) were found to possess high intensity of {111}<112>. {111}<112> has Σ9 coincidence relationship with {110}<001>. Therefore, {111}<112> grains are easily consumed by {110}<001> nuclei during the secondary recrystallization. The influence of the primary recrystallization texture and microstructure on magnetic properties of the material is discussed in details. The effects of primary recrystallization texture on the structure evolution during secondary recrystallization are also discussed.

Th-PB049

INFLUENCE OF STRUCTURE OF POWDER MATERIALS OF SYSTEM Fe-P ON THE STRUCTURAL-DEPENDING PROPERTIES.

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It is known, that the structural-depending properties, such as a coercive force HC and maximal magnetic conductivity of pure iron powdered materials have a strong dependence on the environment of sintering. During sintering these materials in nitrogen atmosphere ($96\%N_2$+$4\%H_2$) the coercive force is incremented practically three times in comparison with HC of materials, sintered in hydrogen. It is caused by dissolution of nitrogen in a lattice of iron. It was shown earlier, that the alloy building by phosphorus reduces solubility of nitrogen, that gives in diminution of a coercive force and magnification of a maximal magnetic conductivity.
However, at concentration of phosphorus 0.65-1% HC of iron powder, sintered in nitrogen atmosphere, has values 108-100 A/m, whereas at materials, sintered in hydrogen it makes 147-128 A/m. This circumstance is not explained by the further diminution of solubility of nitrogen. The exploration of structure has shown, that after sintering at nitrogen atmosphere the materials have a greater size of grain and a smaller pore size.

Th-PB050

STRUCTURE DEFECTS AND MAGNETIC PROPERTIES OF NICKEL FERRITES

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Ferrites with spinel structure concern to magnetically soft materials used in HF and SHF technique. Nickel ferrites with high Curie temperature and small electromagnetic energy losses are most perspective and interesting. The ceramic samples of the nickel ferrites with surplus iron ions content, rapidly and slowly cooled from $1200^{\circ}C$ (10 h) were investigated using X-rays, magnetic, pycnometric and NMR (on ^{57}Fe) methods.
The real structure of nickel ferrospinel (Fd3m) in the tempered specimens is shown to contain Fe^{2+} and high concentration of defects, moreover the vacancies present simultaneously in cationic and anionic sublattices:

$$F_{1-x}^{3+}V_x^{(c)}[Ni_{1-3x}^{2+}Fe_{2+3x-2y}^{3+}Fe_{2y}^{2+}]O_{4-y}^{2-}V_y^{(a)}.$$

In the real structure of slowly cooled samples Fe^{2+} is practically absent, the number of defects is small and lattice contains mainly cationic vacancies, statistically distributed in tetrapositions (according to the NMR data):

$$F_{1-x}^{3+}V_x^{(c)}[Ni_{1-3x}^{2+}Fe_{2+3x}^{3+}]O_4^{2-} \qquad (0 \le x < 0.1).$$

The composition and crystal lattice defects influence on parameter and magnetic properties (σ_s, T_C, H_c, μ_H, $tg\delta/\mu_H$) of slowly cooled non-stoichiometric nickel ferrites. Optimum composition for production of the high quality ferrite materials with required combination of electromagnetic characteristics was determined.

Th-PB051

MAGNETIC ANNEALING OF GRAIN ORIENTED Si STEELS IN THE CONSTANT AND PULSED FIELDS

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The effect of magnetic annealing (MA) under strong combined (constant + pulsed) field on magnetostriction and magnetic properties of grain-oriented (GO) silicon steels has been studied. Magnetic annealing has been undertaken using MA-apparatus, specially designed for treatment of GO electrical steels [1]. It has been found that MA under strong combined (const. + pulsed) field allows an improvement of magnetostriction properties. Major reduction of magnetostric- tion has been observed in the compressed state of material, while the properties of material in the unstressed state and under tension were found to be almost unchanged after MA. The modifica-tion of properties for Si steel with B_{10}=1.88Tesla (B at 1000A/m) is presented in Table 1.

Table 1. Improvement of properties for industrial material with negative magnetostriction.

B_{max}	*ac*-magnetostriction under external stress ($\lambda \times 10^6$)								core losses		
	σ = 0 MPa		σ = -1 Mpa		σ = -2 MPa		σ = -3 MPa		σ = 0 MPa ,W/kg		
	Before MA	after MA	before MA	After MA	Before MA	After MA	before MA	After MA	Before MA	after MA	Δ, %
1.7 T	-2.7	-2.4	-2.9	-1.3	-2.9	-1.4	-2.8	-1.5	1.076	1.07	-0.6%
1.5 T	-1.8	-1.6	-2.2	-0.9	-2.2	-1.1	-2.1	-1.3	0.77	0.755	-1.9%

It can be seen that the properties of material have been improved after MA for various applied stresses and magnetic flux densities, which may have some practical importance for Si steels.

Acknowledgment Dr.Chudakov is grateful to I.P.Bardin Institute (Moscow) for a sabbatical leave

[1] Chudakov I.B., Cha S.Y., Woo J.S., Chang S.K. // Journal of Magnetics, **3**, (1998), p.15.

Th-PB052

SPECIAL FEATURES OF COMPLEX PERMEABILITY SPECTRA IN LASER SCRIBED SILICON STEELS

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Domain refining method is known as one of the most effective techniques for reduction of iron loss of high permeability grain oriented electrical steels. Analysis of the complex perme- ability spectra in laser scribed Si steels allows one to reveal special features of the structure of laser-scribed samples and helps in revealing of optimal laser treatment technological parameters.

The permeability spectra have been decomposed into two dispersions resulted from the reversible and irreversible domain wall motion [1]. In this work, magnetic domain refinement has been performed by the pulsed Nd:YAG laser and the iron loss and the permeability spectra have been measured and analyzed. Frequency spectra of the relative complex permeability, $\mu^*=\mu'-j\mu''$, were measured using an HP4192A impedance analyzer with a 100-turn solenoid coil wound around the rectangular samples. In order to produce an ac magnetic field with constant amplitude on the samples, the amplitude of the ac current applied to the solenoid coil was precisely kept constant by software control during the frequency sweep. Experiments revealed an inverse relationship of permeability with respect to irreversible wall motion and core losses. However, no relationship with the reversible wall motion has been found. The characteristics of permeability spectra - relaxation frequency and permeability components, are discussed in the present work for different types of treatment, according to laser-scribed pattern and energy

[1] S.S. Yoon, C.G. Kim, I.Y. Kim, S.D. Kwon, H.C. Kim // J.Appl.Phys., **85**, (1999), p.6028

Th-PB053

APPLICATION OF A HIGH Al-Si-COATING ON ELECTRICAL STEEL BY HOT DIPPING IN Al-Si-ALLOY

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Steel sheet with a high Si content (>3.5%Si) is difficult to process. These high Si steels are interesting in electrical applications because of the effect of Si on the magnetostriction and the electrical resistivity. Alternative methods have therefore been proposed to obtain high Si-contents, e.g. PVD of Si on sheet steel, followed by diffusion annealing.

As an alternative process, ULC, 3% Si and Ti-IF steel substrates were immersed in hyper-eutectic Al-Si-alloys using conventional sheet steel hot dipping technology with an appropriate surface treatment. Diffusion annealing experiments were carried out to obtain a sufficient amount of Si in solution in the


steel. The tests were carried out with a hypereutectic bath composition, in order to obtain pure Si as primarily solidified phase. The best processing conditions in these experiments were found to be as follows: Al-23%Si melt composition, 820°C melt temperature and 5 sec dipping time. The best results were obtained on a 3%Si steel substrate where primary Si crystals were nucleated (see SEM-image and Si-image on the left) within a matrix of Al-Si eutectic. These coated substrates were, in the second phase of the research, annealed at 800°C for 17h and some also at 1200°C for 5h. The contribution focuses on the microstructural changes in the coating and near-surface region of the steel during the anneal.

Th-PB054

DIFFUSION OF AL AND SI IN ELECTRICAL STEEL AFTER HOT DIPPING IN AN Al-Si-ALLOY AND DIFFUSION ANNEALING

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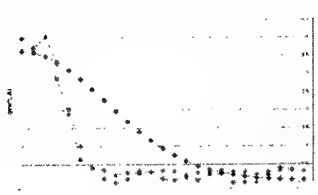
Steel sheet with a high Si content (>3.5%Si) is difficult to process. These high Si steels are interesting in electrical applications because of the effect of Si on the magnetostriction and the electrical resistivity. Alternative methods have therefore been proposed to obtain high Si-contents, e.g. PVD of Si on sheet steel, followed by diffusion annealing.

ULC, 3%Si and Ti-IF steel substrates were immersed in hyper-eutectic Al-Si-alloys during different



times. The temperatures of the substrate and of the molten bath were changed. The mean Al- and Si-content obtained in the substrate after the different diffusion annealing treatments are presented. Some of the annealing treatments are corresponding with typical industrial annealing cycles for coated steel. In the presented experiments, it was only possible to increase these contents with approximately 0.5%.

Calculations of the concentration profiles were performed and compared with the measured results, as e.g. in the enclosed figure. A thorough metallographic examination of the obtained structures was performed and the results are presented in the paper. Various problems during the experiments are the cause of deviations between the calculated results and the measured values. In some cases, during annealing the coating was broken away from the steel substrate. New investigations are carried out at this moment to obtain less decohesion and a deeper diffusion of the elements Al and Si.

Th-PB055

EXPERIMENTAL THERMOMECHANICAL PROCESSING OF HIGH Si-STEELS (UP TO 6.5%Si)

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Good properties for magnetostriction are obtained in steel with a Si-content of 6.5%, but this makes the material extremely brittle and the rolling procedure very difficult. An experimental program was carried out to evaluate the possibility to produce high-silicon steel up to 6.5%Si in final thickness aimed at 0.50-0.35 mm through an adequate rolling scheme, including hot, warm and cold rolling.
Fe-Si-alloys with Si-contents up to 6.5% have been studied. Different melts were prepared in one of the participating laboratories and first hot rolled to a thickness of 25 mm. In these materials, some cracks, inclusions and precipitates (mainly carbides and some TiN) were already observed after this first rolling procedure and quantified. Nevertheless, their interference with the further rolling process was less harmful than would be expected.
To continue hot rolling the slabs were reheated and hot rolled to a final thickness between 2.90 and 1.60 mm. Tensile tests carried out on tested materials after hot rolling showed that all samples are very brittle and the elongation is less than 1%. Samples with lower Si-contents have lower strength than those with higher Si-contents, but they are more ductile. The cold rolling was done obtaining 0.65 mm final thickness in the samples with lower Si-content and 0.9 mm in the high-Si samples. The cold rolling behaviour will be described in detail. Finally the magnetic properties of strips with a thickness of 0.65mm were studied in detail and compared with published results on FeSi-6.5 samples.

Th-PB056

THE ULTRA-SOFT MAGNETIC PROPERTIES OF $Fe_{78}Co_{10}Zr_7B_4Cu_1$ NANOCRYSTALLINE ALLOY

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The nanocrystalline $Fe_{78}Co_{10}Zr_7B_4Cu_1$ alloy was prepared by the single roll rapid quenching method at Ar atmosphere. The structural changes after annealing were investigated by XRD and TEM. The extremely soft magnetic behavior in the annealed sample at 560 °C for 1 hour in a vacuum were obtained, and examined by means of the magnetoimpedance(MI), incremental permeability, coercivity, magnetic anisotropy, etc. Because the MI effect can be obtained only in ultra-soft magnetic materials, the improvement of the magnetic softness by proper thermal treatment was carefully monitored by the MI effect for all annealed samples. The MI measurements were carried out along the ribbon axis with longitudinal magnetic field. The frequency of MI measurement was ranged from 1MHz to 10 MHz, and the current was changed from 10 mA to 50 mA for all measurements. The changes of the incremental permeability as a function of an external field were also measured to verify the magnetic softness along with the MI measurement. The MI ratio coincides with the softness of magnetic properties in the annealed samples and the giant changes of the incremental permeability ratio as a function of the external field.

Th-PB057

HIGH FREQUENCY PERMEABILITY OF PARTIALLY BISTABLE GLASS-COATED MICROWIRES

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Thin amorphous glass covered wires with slightly negative magnetostriction have been submitted to a thermal treatment under an external axial field. It has been proved that such a treatment modifies the domain patterns of the microwires. Whereas the domains of the as cast microwires are basically orthoradial, the treated microwires show an internal axial domain which increases with the temperature of the thermal treatment. The hysteresis loop of those microwires is partially bistable. The parallel permeability $\mu_{//}$ of those wires have been investigated from 50 MHz up to 18 GHz using a new coaxial line perturbation method [1]. In this technique, a network analyzer detects the small perturbation of the impedance of a coaxial line cell loaded by the microwires sample. After correction by the skin effect, one estimates the intrinsic permeability of the microwire. The measured intrinsic permeability parallel to the direction of the wires decreases with the temperature and becomes negligible above 200°C. This is due to the increase of the axial domain and to the release of the stress inside the microwires.

[1] A.-L. Adenot, O. Acher, D. Pain, F. Duverger, M.-J. Malliavin, D. Damiani and T. Taffary, proceeding of the 43rd MMM Conference

Th-PB058

PREPARATION OF 6.5 % SILICON STEEL SHEETS WITH (100) TEXTURE

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Although production of 6.5 % silicon steels is an attractive way to decrease the iron loss of motors, the small magnetic induction prevents us from reducing the size of motors. It is said that formation of (100) texture is an effective way to increase the magnetic induction and that a sulfur atmosphere in annealing enables us to obtain (100) textured thin sheets [1]. However, the sulfur atmosphere makes the mass production of silicon steels difficult because of the corrosion of the production facilities. Accordingly, we reported a new method of obtaining 3 % (100) textured silicon steel sheets, which used a low-vacuum annealing at 1200 °C for 1 h after dipping silicon sheets in sulfur solution (ADS method) [2]. This contribution reports the preparation of 6.5 % silicon sheets with almost (100) plane using a new method.

6.5 % silicon sheets with the thickness of 30 μm were made by using the rapidly quenching method. In annealing, two methods were used. (see Table 1) In Method B, in order to control the number of nuclei of (100) grains, annealing at 1200 °C for 180 s in the vacuum of $1*10^{-6}$ Torr was added before ADS. The atmosphere of ADS was vacuum of 0.01 Torr. Method B enables us to obtain 6.5 % sheets with almost (100) texture. The magnetic induction of 800 A/m, $B_8 = 1.39$ T is larger than that of the conventional 6.5 % silicon sheets (05EX2500 NKK corp.) by about 0.1 T.

Table 1 Preparation of 6.5 % sheets

Method A	Method B
ADS	vacuum + ADS
*71 %	* 92 %
Hc : 59 A/m	Hc : 41 A/m
B_8 : 1.23 T	B_8 : 1.39 T

*area percentage of (100) grains in sheets

[1] G. W. Wiener, J. Appl. Phys., **35** (1964) 856.
[2] M. Nakano et al., IEEE Trans. Magn., **35, No.5** (1999.9) in press.

Th-PB059

THE INFLUENCE OF PbO AND CuO ON THE SINTERING OF Mg-Zn FERRITES

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Mg-ferrite can be easily prepared by ceramic method and has reduced cost. The main problems of this ferrite are its high sintering temperature (above 1300^0C) and low density. A common method to lower the sintering temperature is the use of sintering aids. CuO and PbO having low melting points can contribute to lower of the sintering temperature. Thus, the energy consumption is minimized and the material loss by evaporation is avoided.
In this work the influence of the CuO and PbO on the densification of the MgZn ferrite for various sintering temperatures between 800 and 1100^0C was investigated. By Cu substitution for Mg in $Mg_{0.5-x}Cu_xZn_{0.5}Fe_2O_4$ ferrite (x = 0; 0.1; 0.2; 0.3; 0.4; 0.5) an increase in the density was obtained at relatively low firing temperature (about 1050^0C). Higher densities were obtained by addition of PbO in the ferrite with optimum CuO content (x = 0.3). A spectacular increase in the density at low sintering temperatures (1000^0C) was obtained by doping the ferrite with PbO up to 0.6wt% [1] .
During sintering experiments, a strong compaction of the specimens (of about 50%) was found [2]. From the experimental results, a relation between the density at a proper sintering temperature and the volumic compaction of samples was established.

[1] N.Rezlescu, E.Rezlescu and P.D.Popa, J.Magn.Magn.Mat. **182** (1998) p.199.
[2] E.Rezlescu, N.Rezlescu, P.D.Popa and C.Pasnicu, Mat. Res. Bulletin **33**, 6 (1998) p.915.

Th-PB060

SOFT MAGNETIC MATERIALS FOR OPTIMIZED VIBRATION CONTROL

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The irreversible movement of magnetic domain walls under vibrational stressing is an energy consuming process which can be used for development of high damping materials. Such a magnetomechanical damping is very sensitive to metallurgical state of the material and conditions of applied external stresses, and can be optimized according to chemical composition and thermo-mechanical treatment. In this paper, mechanisms of the magnetomechanical damping in Fe-Cr(Al, Mo) are studied and the influence of Al and Mo additions on the damping capacity are investigated. The experimental works were conducted to determine relationships between the damping capacity, magnetic properties, and microstructure of samples.
Vibration tests were performed over a wide range of frequencies and amplitudes using a cantilever device. The magnetic hysteresis loop parameters were recorded using a computerized hysteresisgraph for measuring DC and AC magnetic properties of soft magnetic materials. SEM and TEM observations showed microstructural modifications that occur during thermal treatment of samples. The damping capacity was found to increase 10-15 times following an appropriate annealing. Lower concentration of Al and Mo doubles the damping capacity, but higher concentrations decreases it drastically due to the formation of secondary phases and Cr-rich precipitates. These behaviors were compared to displacement of magnetic domain walls as observed using magneto-optical Kerr effect.

Th-PB061

STUDY OF THE PROPERTIES OF THE MAGNETIC COMPOSITE MATERIALS ON THE BASIS OF THERMOEXFOLIATED GRAPHITE MODIFIED BY FERRITES

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The results of the researches of structure, magnetic and electrical properties of materials on the base of thermoexfoliated graphite (TEG), modified by ultra-dispersive ferrite particles (barium hexaferrite (BH), strontium hexaferrite (SH) and mixed strontium-barium ferrite) are presented. Magnetic composite materials (MCM) were prepared both with polymer binders (polypropylene, polyvinylchloride, polytetrafluorethylene) and without them. The contents of magnetic components varied from 5 up to 55,5 weight %, that of polymer - from 5 up to 50 weight %. To study the structure of modified TEG particles and their surface, optical, scanning electron microscopy and X-ray diffraction methods were used. Magnetic characteristics of MCM were determined using vibromagnetometer, specific volumetric electrical resistance was determined by a four-probe method. For the first time it was founded that modification of TEG surface by BH and SH while TEG synthesis and subsequent technological processes of manufacturing enables to obtain MCM, the magnetic characteristics of which essentially differ from those on the basis of BH and SH powders. Developed MCM have narrow hysteresis loops, small residual magnetization, and low magnetic loss. It was shown, that magnetization processes and the properties of MCM depend essentially on the BH concentration, characteristics of the TEG and ferrite surfaces, a degree of atomic disorder, peculiarities of cluster components formation.

Th-PB062

DESCRIPTION OF COMPLEX RESPONSE OF MAGNETIC FIELD ENERGY IN MATERIALS

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Proposed description of complex frequency response gives a general view to the power losses and to accumulated magnetic field energy of load of sample or device. Using this method it is better possible to determine the independent hysteresis losses and relaxation losses from physical point of view. The relaxation losses are associated with total eddy current losses and include also so–called excess losses for electrically conductive materials [1]. For magnetic dielectric materials the relaxation losses are associated with spin–spin or spin–lattice interactions. It can be shown that for both kinds of magnetics the appropriate relaxation distribution parameters can be used to estimate the parts of relaxation effects which contribute to frequency dependent losses.

[1] Bertotti G.: IEEE Trans. on Magn., 22 (1998), pp. 621-630

Th-PB063

ESTIMATION OF THE CONTRIBUTION OF HIGHER HARMONICS TO POWER LOSSES IN THE LAMINATED CORE OF AN INDUCTOR DRIVEN BY PERIODIC RECTANGULAR VOLTAGE WAVEFORM

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It is assumed that the inductor having core made from magnetic material for which losses rise with amplitude B_m of harmonic magnetic flux density as $P_h \sim B_m{}^n$, n is close to 2; can be considered as a linear device.

The total power losses at nonharmonic waveform $B(t)$ can then be evaluated as a sum of power losses due to single harmonic components of $B(t)$. The total specific power loss is then:

$$P \sim \left(\frac{B_m}{B_{m1}}\right)^n \cdot \left[P_0 \cdot \sum_{k=0}^{\infty}\frac{1}{(2k+1)^{2n-1}} + a \cdot \sum_{k=0}^{\infty}\frac{1}{(2k+1)^{2n-2}} + b \cdot \sum_{k=0}^{\infty}\frac{1}{(2k+1)^{2n-\frac{3}{2}}}\right] \quad (1)$$

P_0, a, b are constants depending on material and reference frequency f_1.

The weight of $(2k+1)^{\text{th}}$ harmonic is given by the sum of three terms as in (1) for selected k only. For FeSi 3% oriented sheets, $n = 1.8$, $f_1 = 200$ Hz, the weight of harmonics is given in the Table.

$2k+1$	3	5	7	9
weight (%)	9	3.2	1.7	1

Th-PB064

THIN FILM SOFT MAGNETIC Fe-Zr-Al-N-O ALLOYS.

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Soft magnetic materials with high saturation flux density (~2T) and hardness (Hm~10GPa) are required for magnetic head cores operating in a contact with high-coercive and hard storage media. Nanocrystalline Fe-rich alloys containing metals of III, IV, V groups and interstitial elements can provide such level of the properties.

In this investigation thin films of Fe - 1.5 at.% Zr - 1.5 at.% Al - N - O alloys were prepared by a magnetron sputtering of Fe-Zr-Al targets in atmosphere of Ar containing both N_2 and O_2. Partial pressure of N_2 (P_{N2}) and O_2 (P_{O2}) were varied from 0 to 15% and from 0 to 5% of total pressure (0.66 Pa) correspondingly. An original design of the sputtering unit, which provided high sputter rate of high magnetic conductive Fe-rich target, was developed.

X-ray spectral microanalysis showed that an increase in P_{N2} resulted in monotonous increase in concentration of nitrogen in the film (C_N) from <1 to 15 at.%. Meanwhile an increase in P_{02} only to 3% resulted in an increase in concentration of oxygen in the film (C_O) up to 6-7 at.% without any change in C_O under further increase in P_{O2}. X-ray diffraction analysis showed that both a parameter and a defectness of crystal lattice increased with the increase in concentration of interstitial elements in the film. Partial amorphization of the film took place at C_N = 10-15 at.% and C_O = 6-7 at.%. A vacuum annealing of as-sputtered films at 400^0C and 550^0C resulted in the crystallization of the amorphous phase. The annealing as showed to decrease in C_N without any change in C_O.

Th-PB065

CATION DISTRIBUTION AND MAGNETIC INTERACTION IN $Y_3Fe_{5-x}Cr_xO_{12}$ BY MÖSSBAUER SPECTROSCOPY

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Garnet containing iron has been examined by ^{57}Fe Mössbauer spectroscopy and vibrating sample magnetometer(VSM). The results show that Cr in $Y_3Fe_{5-x}Cr_xO_{12}$ compounds (x = 0.0, 0.25, 0.5, 1.0) is distributed at octahedral site. The substitution of Fe^{3+} by Cr^{3+} on the octahedral site results in much lowering of magnetic ordering temperature. The Mössbauer spectra can be analysed by 3set or 4set of 6 Lorentzians with increasing an amount of Cr^{3+}. It results from the distribution($_4C_n$) of Fe^{3+} and Cr^{3+} at octahedral site. The ratios of areas, a, d_1, d_2, d_3, in $Y_3Fe_{4.5}Cr_{0.5}O_{12}$ are 0.33, 0.22, 0.28, 0.14. The saturation magnetization and the coercivity decrease with Cr^{3+} increasing.

Th-PB066

INFLUENCE OF ELECTRIC FIELD ON SPECTRUM OF NMR IN CENTERANTISYMMETRICAL ANTIFERROMAGNETICS

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The paper investigates an influence of the electric field **E** on spectrum of NMR frequencies in centerantisymmetrical antiferromagnets, which can have a linear magnetoelectrical (ME) effect. It is shown that there are two channels affecting **E** on the NMR spectra: the trivial mechanism through the summary ME magnetization $\mathbf{M}_E$, and directly through the antiferromagnetic vector **L** giving independent contribution to the local magnetic field ($\propto L_iE_j$) on nuclear spins. Just the LE–channel can lead to additional splitting of the NMR spectrum by the field **E**. Results allow getting additional information about magnetic structure by NMR in the presence of electric field. The effect was considered in dependence on crystal and magnetic structures and orientation state. The trigonal oxides (such as Cr_2O_3) and tetragonal trirutiles (Fe_2TeO_6 etc.) are investigate as examples.

Th-PB067

INCOMMENSURATE STRUCTURES OF CRYSTALS WITH TRIANGULAR ARRANGEMENT OF MAGNETIC IONS

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Modulated magnetic structures (MMS) that are symmetrically specified are considered in the crystals of Fe_2P type with triangular arrangement of ionic magnetic moments. From the point of view of the phenomenological theory the existence of such MMS is specified by the presence of invariants in the non- equilibrium thermodynamic potential. This invariants are linear of first-order derivatives with respect to irreducible magnetic vectors (IMV) with respect to space components and take place the competition of this invariants with invariants, that are quadratic with respect to this derivatives.

It is shown that inclusion of invariants containing multiplications of IMV, which transformate in different irreducible representations, changes the picture of the phase transitions (PT) in the system. Thus, taking the biquadratic exchange into account lead to the appearance of few superstructures. The PT in this case can be both of the first- and the second-order. A refusal of approximation of the of the IMV module permanency leads to the appearance of double MMS. Substantively there are changing of both modules of IMV and the phase of mutual arrangement at these circumstances.

Th-PB068

SELFINDUCED ANTIFERROMAGNET TRANSPARENCY FOR THE MAGNETIC FIELD PULSE

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The unidimensional spin XY-chain with the condition of strong anisotropy of exchange interaction $J_x = - J_y$ allows to obtain its exact evolution equation system. Namely under this condition was shown [1] the possibility of zero response on the homogeneous magnetic field, certainly altering in time. The magnetic properties of organic compounds of TCNQ salts class may be explained in the framework of the considered model with the antiferromagnetic ground state.

The $J_x = -J_y$ condition reduces the equation system to the form which is known to have a soliton solution. The possibility of resonance soliton passage without dissipations in the magnetic is shown by finding the automodel uniparametric solution $\hbar \cdot n(v) \cdot ch^{-1}(n(v) \cdot (t - x/v))$. The presence of such a nonlinear excitation causes the effects like the selfinduced optical transparency, sound propagation in the superconductors. It is conditioned mainly by the fermian character of elementary excitations in correspondent systems.

The obtained result gives the criteria of the sample choice for experimental study of possibility for the magnetic field pulse pass through without dissipations and the pulse characteristics as well.

[1] Borovik A.E., Borovikov V.S., and Frishman A.M. // Phys. Lett. A, 140, (1989), p.436.

Th-PB069

MAGNETISM AND CRYSTAL-FIELD INTERACTIONS IN *3d* AND *4f* COMPOUNDS

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The strong correlation between the local crystal-field symmetry and the atomic-scale magnetism has been theoretically found. These results are compared with numerous experimental data for compounds like $LaCoO_3$, $FeBr_2$, $PrNi_5$ and $NdNi_5$ and very remarkable reproduction of experimental results for the ordered magnetic moment, the formation of the non-magnetic state, temperature dependence of the magnetic susceptibility and other properties has been revealed. It turns out that in these compounds having incomplete 3d and 4f shells there exists the fine electronic structure associated with the local highly-correlated electronic systems $3d^n$ and $4f^n$. This fine electronic structure depends on the intra-atomic spin-orbit coupling and crystal-field interactions, the latter being the effect of interactions of aspherical anisotropic charge distribution of the incomplete electronic shell with the charge multipolar interactions. The existence of this fine electronic structure with the energy separation even smaller than 1 meV affects substantially the electronic and magnetic properties of the whole compounds, at low temperatures in particular in agreement with numerous experimental observations. Our calculations reproduce well the temperature dependence of the heat capacity and magnetic susceptibility.

Th-PB070

PHYSICAL PROPERTIES of Co/Co_xSi_y and Si NANOPARTICLES IN NANOWIRES

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Electronic structure of Co/Co_xSi_y and Si nanoparticles has been detected from investigations of tunnel current spectroscopy features into $Co/Co_xSi_y/Si$ nanowires without and with magnetic field (normal and parallel to nanowires).
The systems of $Co/Co_xSi_y/Si$ nanowires on the Si(100) surface and into bulk Si were formed using the Co implantation and characterized by TEM, XPS and AES [1]. $Co/Co_xSi_y/Si$ nanowires physical properties versus size of nanoparticles Co/Co_xSi_y (20-50 nm) and Si (5-20 nm) were revealed.
The analysis of results in comparison with theoretical calculations showed that electronic states in nano-Co/Co_xSi_y are similar to the states in bulk with band of discrete states near the Fermi level. The bands of electron states are present into nano-Si with band gap of 1.4-2 eV and are high sensitive to the orientation of magnetic field.

[1] I.Belousov, P.Kus, S.Linzen, P.Seidel // Solid-State Electronics, 43, (1999), p.1101.

Th-PB071

NUCLEAR MAGNETIC RESONANCE IN FERROMAGNETIC $CuCr_2S_4$:Sb.

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The copper sulfochromite demonstrates a charge-nonequivalence because the Cu^+ ions occupy tetrahedral sites unlike the ideal spinel which contains bivalent ions in these sites. The Cr^{3+} ions as well as Cr^{4+} ions occupy octahedral sites in order to compensate a valency. The influence of such charge-nonequivalence on NMR spectra is the object of present study.

Polycrystal samples of ferromagnetic $CuCr_{2-x}Sb_xS_4$ with x=0, 0.02, and 0.15 have been used to observe spin-echo signals from ^{53}Cr, ^{63}Cu and ^{65}Cu nuclei at T = 77 K. The crystals studied have a spinel structure with Cu^+ ions occupying tetrahedral sites, which symmetry is cubic in the ideal spinel. Multiquantum echo-signals detected experimentally for both ^{63}Cu and ^{65}Cu nuclei of spin I = 3/2 indicate that the non-zero electric field gradient takes place in tetrahedral sites. Assuming that both Cr^{3+} and Cr^{4+} ions occupy octahedral sites of a spinel structure, we have simulated NMR spectra of copper and chromium nuclei. The point electric charge and point magnetic dipole models have been used to compute electric field gradient and local magnetic field, respectively. The calculated spectra have been averaged for all directions of magnetization, that corresponds to nuclei situated be in walls. Only one manipulated variable which is the antishielding factor has been use to achieve a good agreement between calculated and experimental spectra.

The exponential spin-echo decay has been recorded experimentally. The nonsecular contribution into spin-echo decay has been estimated using the difference between relaxation rates of traditional 2τ and multiquantum 4τ echoes. The possible mechanisms responsible for a dependence of transverse relaxation time on resonance frequency are discussed too.

Th-PB072

MAGNETIC AND RESONANCE PROPERTIES OF CuB_2O_4 SINGLE CRYSTALS

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High quality CuB_2O_4 single crystals with space group $I\bar{4}2d$ have been grown.

The jump of the susceptibility and its following growth with further temperature decreasing were obtained at T=20 K for external magnetic field $H_\perp$ lying in basal plane. Under further temperature decreasing the sharp abrupt of the magnetic susceptibility was obtained at T_c depending on $H_\perp$ (T_c=10 K and 4.2 K for $H_{c\perp}$= 50 Oe and 12 kOe respectively). In contrast, the susceptibility curve for H parallel to c-axis revealed no features and monotonously grows with temperature decreasing.

The magnetization measurements in temperature range 10-20 K have revealed the existence of a weak spontaneous magnetic moment in basal plane of the crystal.

The frequency-field and temperature dependences of antiferromagnetic resonance parameters of tetragonal CuB_2O_4 single crystal are investigated. It is confirmed that high temperature state below T_N=20 K is easy plane weak ferromagnet. The temperature dependence of Dzyaloshinsky's field is measured. At T=4.2 K and $H \perp C_4$ the frequency-field dependence exhibits a jump at $H_{c\perp}$=12 kOe which is concerned with the phase transition from the low temperature state to the field induced weak ferromagnetic state. The resonance investigations allow to suggest that in low temperature state magnetic moments remain in basal plane but the spontaneous magnetic moment is absent.

The $H_\perp$-T phase diagram of CuB_2O_4 is given from resonant and magnetic measurements.

Th-PB073

MAGNETIC ORDERING IN THE $ZrNi_{1-x}Cr_xSn$ COMPOUND

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The static magnetic properties and the X-band electron paramagnetic resonance (EPR) spectra of $ZrNi_{1-x}Cr_xSn$ solid solution (x=0.005; 0.01; 0.05; 0.10; 0.20; 0.25; 0.30; 0.40) were investigated in the 77÷300 K temperature range. The solid solution samples based on semiconducting ZrNiSn ternary compound were prepared by arc-melting of the pure metals. The X-ray analysis of the samples has shown the MgAgAs crystal structure type (space group - $F\bar{4}3m$) up to $x \leq 0.4$. The temperature dependence of a dc magnetic susceptibility for $ZrNi_{1-x}Cr_xSn$ ($0.005 \leq x \leq 0.2$) alloys can be described approximately by Curie-Weiss law. However, for small Cr concentrations, the ferromagnetic ordering occurs. The pure ZrNiSn compound as well as the $ZrNi_{1-x}Cr_xSn$ (x=0.25; 0.30; 0.40) solid solution are Pauli paramagnets.
EPR spectra of the samples with x=0.05; 0.10; 0.20 consist of two absorption lines: broad with ΔH_{pp} of about 120 G (I type) and narrow with ΔH_{pp} of about 10 G (II type). Both EPR lines belong to Cr^{3+} ($3d^3$, $^4F_{3/2}$) ions. The I type spectrum belongs to Cr^{3+} ions in the Ni-sites of lattice coupled by magnetic dipolar interaction. The II type spectrum belongs to exchange coupled Cr^{3+} pairs or clusters of more than two Cr^{3+} ions. The features of magnetic dipolar and exchange interactions of the Cr^{3+} ions in the $ZrNi_{1-x}Cr_xSn$ lattice are discussed.

Th-PB074

MOSSBAUER ANALYSIS OF THE HYPERFINE INTERACTIONS IN THE F.C.C. Fe-Cr-Mn-Ni-C(N) ALLOYS

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The scattering and transmission Mossbauer spectra of the Fe-18%Cr-10%Mn-16%Ni-(0.0-0.5)%N and Fe-17%Cr-9%Mn-14%Ni-(0.001-0.77)%C alloys after solution treatment at 1100°C and water quenching were obtained and their hyperfine structure was analyzed. The approximation model of the spectra was proposed.
The change of isomeric shift of the spectra components with increasing carbon and nitrogen concentration was revealed and attributed to the effect of nearest interstitial atoms on the *s*-electron density at the iron nuclei. No change of the recoil-free fraction and hyperfine magnetic interaction parameters was detected that points to the stable interatomic bonds in austenites. The curves are compared with the concentration dependences of Debye temperature derived from the low temperature measurements of the electronic heat capacity and with the data obtained by means of the inelastic neutron scattering [1].

[1] V.G. Gavrilyuk, V.M. Nadutov, S.A. Danilkin et. al. // Mater. Sc. Eng., A203, (1995), p.300.

ThPB075

EFFECT OF STRONG PULSED MAGNETIC FIELD ON SPIN-ECHO SIGNALS OF NUCLEI ARRANGED IN DOMAIN WALLS OF MAGNETICS.

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For the first time theoretically was anticipated and experimentally observed so called magnetic echo (ME) signal formed by nuclei arranged in domain walls (DW) of magnetics [1] when magnetic pulse (MP) was applied in combination with RF pulse.
It was shown that ME is formed at sufficiently fast changes of effective magnetic field in rotating frame of reference when nuclei changed their local positions in DW under the action of MP-es causing changes of local hyperfine fields and RF pulse enhancement factor.
This conclusion is supported by the nuclear echo signals formed at pulsed changes of frequency in the limits of RF pulse.

The effect of strong MP on formation of so called Mims echo was also investigated [2].

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Th-PB076

MÖSSBAUER STUDY OF IRON NITRIDES PROPERTIES

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The properties of iron nitrides may be interesting for various applications because the average magnetic moment of α'' $Fe_{16}N_2$ phase seems to be higher than that of α Fe. We have prepared the mixtures of the iron nitrides by nitriding iron powder in various ratios of H_2 and NH_3 at 750°C, quenching to liquid N_2 and annealing at 130 – 150 °C. Some of the materials were milled in various atmospheres before final anneal. The final product of preparation contained α Fe, γ FeN_x, α' FeN_x and α'' $Fe_{16}N_2$ and the defect phase. The results obtained by XRD, neutron diffraction, and Mössbauer spectroscopy with the final products confirmed the presence of the desired α" phase, but the quantitative data differed due to the specific features of the method employed.
Mössbauer spectra were taken in the transmission mode with the ^{57}Co in Cr; most of the spectra were acquired at 300 K. On the one hand the average magnetic moments per Fe atom μ_{Fe} were calculated from the measured magnetic moments of the samples with the use of the analysed nitrogen content of the final product and on the other hand they were also derived from the measured hyperfine fields and the concentrations of Fe in various types of sites and/or phases. For the conversion of the hyperfine field to local magnetic moment the coefficient of proportionality for the given phase was used as critically listed by Coey [1]. These two sets of data were in a good mutual agreement with σ ranging from 240 to 246 emu/g (maximum difference of about 5 %).

[1] J.M.D.Coey, J.Appl.Phys. **76**(1994) 6632-6636

Th-PB077

SUM RULES ON THE DYNAMIC PERMEABILITY OF MAGNETIC MATERIALS AND COMPOSITES

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For bulk ferrites, it is well known that there is a tradeoff between the permeability levels and the gyromagnetic resonance frequency. It is expressed by Snoek's law, and similar relations can be derived for saturated ellipsoids. However, no such quantitative rule has been established in the more general cases of unsaturated or composite materials. The aim of this paper is to report a sum rule on the dynamic permeability, which yields a bound on the high frequency characteristics of bulk and composites materials:

$$\int_0^{+\infty} F\mu''(F)dF \le \frac{\pi}{2d}\left\langle \gamma.4\pi M_s^{\,2} \right\rangle$$

F is the frequency, $<(\gamma.4\pi M_s)^2>$ the spatial average of the square of the gyromagnetic ratio times the saturation magnetization, and d=3 for an isotropic material. This relation holds provided the internal fields are small compared to the saturation magnetization, no skin effect occurs, and the damping term is Bloch-Bloembergen type. The validity of this relation is checked experimentally on a number of materials. The permeabilities of bulk and dispersed ferrites and of ferromagnetic-based samples are reported in the 0.1 to 18 GHz frequency range, and the quantity I_x is calculated. It is shown that the majoration holds for all the samples, and that the bound can be attained. The choice of the damping term is discussed.

Th-PB078

MAGNETIC PROPERTIES OF THE $Y_{1-x}Bi_xBa_2Cu_3O_{7-\delta}$ SUPERCONDUCTING SYSTEM

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A.C. magnetic susceptibility measurements were performed on samples belonging to the $Y_{1-x}Bi_xBa_2Cu_3O_{7-\delta}$ superconducting system prepared by solid state-reaction route. The partial replacement of yttrium with bismuth in the not-fully oxygenated samples determines an improvement of the intergranular coupling for low levels of substitution ($x \le 0.1$). This behaviour is assigned to the formation of the $BaBiO_{3-x}$ phase at the surface of the Y-123 grains, detected from the X-ray diffraction analyses. When the substitution degree exceeds x = 0.1 the intergranular coupling becomes weaker because of the Y-123 phase fraction diminishing. The A.C. susceptibility results from samples with low substitution degree ($x \le 0.05$) which were further oxygenated indicates that the $BaBiO_{3-x}$ phase favourites the oxygen diffusion into the Y-123 grains and rises the critical temperature. On the other hand the ulterior sample oxygenation leads to a weak intergranular coupling in the superconducting samples.

Th-PB079

EXTERNAL FIELD INFLUENCE ON PHASE SEGREGATION IN MAGNETIC ALLOYS AND FLUIDS.

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We study a lattice system consisting of several kinds of spin carrying particles. The Hamiltonian

$$H = -\sum_{\langle ij \rangle} K_{ij} S_i S_j - \sum_i h_i S_i - \sum_{\langle ij \rangle} V_{ij} - \sum_i \mu_i$$

includes ferromagnetic ($K_{ij} > 0$) and nonmagnetic (V_{ij}) interactions between nearest neighbor particles, external magnetic field (h_i) and chemical potential (μ_i) contributions. Coupling constants are sort-dependent

$$K_{ij} = \sum_{\alpha\beta} K_{\alpha\beta} X_{i\alpha} X_{j\beta}; V_{ij} = \sum_{\alpha\beta} V_{\alpha\beta} X_{i\alpha} X_{j\beta}; h_i = \sum_{\alpha} h_\alpha X_{i\alpha}; \mu_i = \sum_{\alpha} \mu_\alpha X_{i\alpha}$$

$X_{i\alpha} = 1$, if the site i contains a particle of the sort α, otherwise $X_{i\alpha} = 0$. Chemical potentials μ_α should be found from the relation $c_\alpha = \langle X_{i\alpha} \rangle$, where c_α is the concentration of the particles of the sort α, angle brackets denote thermodynamic averaging.

In the absence of the external field ($h_\alpha = 0$) the model possesses of the second order phase transition to the ferromagnetic phase. In addition, both the magnetic and nonmagnetic interactions can induce the sort segregation. We have found that an external magnetic field can both enhance and suppress the segregation of the binary mixture, depending on the model parameters. Qualitative explanation of these different effects is suggested.

Th-PB080

ELECTRONIC RAMAN SCATTERING IN MAGNETOELECTRIC $LiCoPO_4$

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High values of magnetoelectric coefficients found in $LiCoPO_4$ set it in an unique place in the family of lithium orthophosphates $LiMPO_4$ (M=Co, Ni, Mn, Fe). The nature of this phenomenon is not clear and solution may lie in specific arrangement of the energy levels of the magnetic ion Co^{2+}. Raman spectra of the single crystal have been measured above and below Neel temperature (T_N=21.9 K) within an energy range 0—1200 cm^{-1}. Spectral features due to first-order scattering from phonons and Co^{2+} electronic excitations are analyzed and assigned to symmetry species. An energy level scheme appropriate to Co^{2+} ions in $LiCoPO_4$ have been determined and compared with calculated earlier.

Strong coupling between an electronic transition in the $^4T_{1g}$ (^4F) manifold of Co^{2+} and the optical phonons has been observed. The Raman spectrum in the region of 215 cm^{-1} is temperature dependent and shows a marked change at T_N. Well above T_N, the spectrum contains nearly symmetric band which becomes asymmetric with temperature lowering. Well below T_N, two sharp features coexist. More complicated picture of electron-phonon coupling was observed in the region of 1000 cm^{-1} where two vibrational excitations interact with the electronic one. In the low temperature experiments a light scattering from spin-waves was observed also.

Th-PB081

IDENTIFICATION OF MULTIPLE SPIN-DENSITY WAVE STATES BY INFRARED

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Multiple spin-density waves (MSDW) are known states, frequently referred to as multi-k structures (k is a wave vector of magnetic structure). Thus, they are stabilized in widely applied Mn-based alloys [1], and variety of homogeneous and inhomogeneous magnetic systems. However, a long-standing problem of determination of multi-k structures (in comparison with the sets of domains) still exists, in particular, for MSDW helices [2]. We propose theoretical background for a new, effective and low-cost, method of identification of multi-k structures by means of infrared spectroscopy and analysis of the magnetic-ordering-dependent one-phonon (first order) light absorption spectra. This method has been employed already for investigation of homogeneous structure [3], however, it would be even more effective for inhomogeneous ones with essential contribution of exchange interaction to formation of electric-dipole moment of the crystal.

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Th-PB082

LOW TEMPERATURE PHASE TRANSITIONS IN DOPED MAGNETITE

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The investigation of low temperature Verwey transition and spin reorientatinal (SR) one in Sn^{4+} doped magnetite was carried out. Its cation distribution is as follows: $Fe^{3+}_{x-y}Sn^{4+}_{y}\left[Fe^{2+}Fe_{1-\frac{4}{3}x+y}Sn^{4+}_{x=y}\,{}_{\frac{1}{3}x}\right]O^{2-}_{4}$. The effects of impurities and vacancies implanted in the magnetite lattice was were studied by means of dilatometric methods.It should be noted that the phase transition temperature essentially decreases but the temperature change rate with impurity concentration increasing for every transition is its own ($\frac{\Delta T_V}{\Delta x} = 60\,{}^{K}\!/_{ion}$ and $\frac{\Delta T_{SP}}{\Delta x} = 50\,{}^{K}\!/_{ion}$) The composition where x=0,18 is a restricted one as the its concentration for the Verwey transition still observed ($T_V = 20K$). If the composition includes x=0,24 a single SR transition is found $(T_{SP} \approx 20K)$. Various critical temperature change rates allowed both phase transitions to be investigated. They are practically unseperable in undoped magnetite.

Th-PB083
ANOMALY OF LONGITUDINAL ACOUSTIC MODE IN Fe_3BO_6

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The compound Fe_3BO_6, is isomorphic to rare-earth orthoferrites for $T < T_n = 508K$, and is a weak orthorhombic ferromagnet which undergoes a reorientation at $T = T_{sr} = 415K$. Its (H-T) phase diagram is well known and does not have any peculiarities in the temperature range 70K - 140K.
The necessary measurements were done using a pulsed ultrasound spectrometer. The longitudinal acoustic modes with a frequency 30MHz and $q\|a$ (q - acoustic wave vector, a crystallographic axes) were excited by a resonant lithium-niobate piezoelectric transducer. Measurements of sound attenuation were conducted in the continuous regime with an automatic recording instrument. We find that the absorption of the longitudinal acoustic wave in the temperature range 70K -140K catastrophically increases and shows considerable hysteresis on the low temperature edge (15-30K).
Suggested model of the phenomena assumes layered metallization of the sample (due to metal-dielectric-metal phase transition) in the studied temperature range. Metallization occurs in (111) (112) and (hk0) atomic planes and the structure undergoes amorphization. Analogous model can be used to describe the anomalies found in layered manganite crystals LaSrMnO [1]

[1] C.D.Potter, M.Swiatek, et al. // Phys.Rev.B, v.**57**, p.72 (1998).

Th-PB084
NMR STUDY OF Ni_2MnGa COMPOUNDS.

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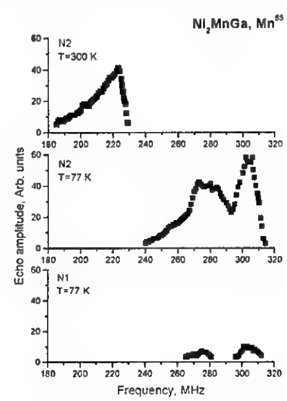
The compounds with magnetostimulated martensitic transformation attract the attention last few years. The characteristics of these materials strongly depend on the distribution of atoms near Mn ions. Thus NMR technique is very useful for these compound investigations.
Two alloys $Ni_{50}Mn_{29.5}Ga_{20.2}$ (N1) and $Ni_{48.7}Mn_{30.1}Ga_{21.3}$ (N2) were melted in induction furnace in argon atmosphere. The composition of the alloys was measured by WDS. After homogenization at 1000°C during 3 days and aging at 800°C 1day the alloys were cooled to room temperature. Martensitic transformation points M_s, M_f, A_s, A_f and Curie point T_c were measured low field *ac* magnetic susceptibility technique (for N1: M_s=71°C, M_f=64°C, A_s=74°C, A_f=78°C, T_c=97°C; for N2: M_s=29°C, M_f=26°C, A_s=32°C, A_f=35°C, T_c=99°C). The powder for NMR measurments was prepared by ball milling and heat treated after preparation at 800°C for 30 minutes quartz ampoule to remove the mechanical strain.
Spin echo techniques was used for the investigation at room and LN_2 temperatures. The obtained NMR spectra are represented in Figure. The correlation between NMR data and magnetic and structural properties of these compound is discussed in this work.



Th-PB086

MAGNETO-OPTICALLY REVEALING OF MAGNETIC FIELD-INDUCED NEW PHASE TRANSITION IN THE MAGNETOELECTRIC $LiCoPO_4$ CRYSTAL

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The aim of the present work was to investigate a behaviour of magnetooptical properties of magnetoelectric $LiCoPO_4$ crystal (T_N= 21.9K, according to the earlier neutron diffraction investigations its Shubnikov group is Sh_{62}^{445} = Pnma') that has exceedingly high value of the linear magnetoelectric effect.
The measurements of linear birefringence and Faraday rotation were performed at a magnetic field and light directed along the crystallographic axis *b*, parallel to the antiferromagnetic vector. The magnetic field dependence of the birefringence has the square-law character. The linear birefringence has sufficiently high values as to serve as tools for the studies of this interesting magnetoelectric crystal. The peculiarities of the birefringence are (i) its high value comparing to the spontaneous one in the field near 40 kOe much lower than effective exchange field and (ii) step-like changes in the relatively low fields (H~20kOe at T=15K) accompanied with the significant magnetic field hysteresis. Experimental data it is evident that the magnetic structure of the crystal is more complicated that was assumed in the earlier studies. The possible structures and their changes in the magnetic field are discussed

Th-PB086

INDUCED BY MAGNETIC FIELD STRUCTURAL PHASE TRANSFORMATIONS IN PARAMAGNETIC JAHN-TELLER CRYSTAL OF KDY-MOLYBDATE

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This repot concerns to problem of the magnetic field influence on structure of paramagnetic crystal. The subject of the present studies is the layered double KDy-molybdate, which undergo the Janh-Teller ordering of a nonferrodistortive type.
Here we report on magnetic and magneto-optical investigation of the spontaneous and magnetic field induced lattice transformations in this crystal. We focused our attention on the intermediate crystal phase formed at destroying of antiferrodistorsive ordering. Peculiarities of appearance and destroying of the intermediate state by magnetic field or influence of temperature are next. The low-field (H_1) transition is accompanied with small step-like changes of a linear birefringence and magnetization with characteristic hysteresis loops. The high-field (H_2) transition is smooth ones. These peculiarities suppose that the intermediate phase is the incommensurate phase. The structural phase diagram (H(*ac*), T) of the paramagnetic KDy-molybdate crystal was constructed. The interval of magnetic fields, where there is the intermediate phase ($\Delta H = H_2 - H_1$), did not change almost with deviation of magnetic fields from the axis with extreme values of the g-factor of Dy^{3+} sites in the (***ac***) plan on angles up to 15 degrees.

Th-PB087

Withdrawn

Th-PB088

MAGNETIC PROPERTIES OF QUASI-ONE-DIMENSIONAL SPIN ½ Cu CHAINS IN $Pb[Cu(SO_4)(OH)_2]$

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Magnetic properties of $Pb[Cu(SO_4)(OH)_2]$ have been studied as a function of temperature (from 2 K to 300 K) and magnetic field up to 50 kOe. Magnetic measurements were performed in various magnetic field orientations in respect to the main crystallographic axes.
The results of magnetic measurements were correlated with specific heat measured in temperature range 0.5-20 K.
The structure of $Pb[Cu(SO_4)(OH)_2]$ contains a roof-shaped staggered Cu-O ribbons composed of CuO_4 squares sharing edges. The studied compound can be described as an quasi-one-dimensional Cu^{2+} (S=1/2) magnet with non-magnetic ground state and non-zero energy gap in the excitation spectrum. It has been shown that due to interchain interactions a long-range antiferromagnetic order develops below 3K. The properties of $Pb[Cu(SO_4)(OH)_2]$ are discussed in terms of various theoretical models.

The work was partly supported by Polish State Committee for Scientific Research (KBN) under project No 2 P03B 102 14.

Th-PB089

CONTRIBUTION OF LONGITUDINAL OSCILLATION OF MAGNETIZATION TO $SmFeO_3$ RESONANCE PROPERTIES

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It is known [1], that field dependence of energy gap in the spin-wave spectrum ν on the product $(\chi_{\|} / \chi_{\perp})^{1/2} \cdot H_{tr}$, where $\chi_{\|}$, $\chi_{\perp}$ is the longitudinal and transverse susceptibility and H_{tr} is the transition field, is the evidence of the longitudinal oscillation of magnetization contribution to resonance properties of orientational phase transitions. So corresponding effects in the vicinity of the low temperature spontaneous transitions ($\chi_{\|} / \chi_{\perp}$, Htr $\rightarrow$ 0) are small. These transitions are inherent practically to all rare-earth orthoferrites (R - Yb, Ho, Er, Tm, Dy, Nd). Only $SmFeO_3$ is an exception. It's spin reorientation takes place at relatively high temperature Ttr $\approx$ 480K, what corresponds to $\chi_{\|} / \chi_{\perp} \approx 0,7$. At present $SmFeO_3$ is the only orthoferrite, in which effects of manifestation of longitudinal oscillations in the vicinity of spontaneous transitions, i.e. in low fields, has been a success. At H $\rightarrow$ 0 these effects are characterized the gradients $\partial\nu/\partial T \approx 0,5$ GHz/K and $\partial\nu/\partial H \approx 1,67$ GHz / kOe, whereas the experiments on majority of enumerated orthoferrites have done us zero value of these derivatives.

[1] A.M.Balbashov, Yu.M.Gufan, P.Yu.Marchukov and E.G.Rudashevskii // JETF **67,** (1988), p.821.

Th-PB090

FERROMAGNETIC ORDERING UNDER A NON-LINEAR EXCHANGE INTERACTION

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According to various theoretical concepts in magnetism, i.e. Bethe-Slater-, RKKY-, Stoner-Wohlfahrt theories, the dependence of the Curietemperature on interatomic distance can have extrema. In an expansion of the exchange integral Jab(r) versus interatomic distance r close to these extrema, the quadratic term of the expansion dominates. The consequences for a magneto-strictive paramagnetic-ferromagnetic phase transition under these conditions are discussed, i.e. supermagnetostriction and (hidden) magnetic states which can be brought forward using strong external magnetic fields. By choosing the parameters of the expansion different, we find four different types of p -T phase diagrams. It is important to note that the calculation of the magnetisation curves M (p, H,T) and of the phase diagrams does not require an (Landau-) expansion close to the critical point Tc.

[1] K. Bärner, E. A. Zavadskii, D. Yu. Suminov, phys. stat. sol (b) 214 (1999) 411

Th-PB091

MAGNETIC AND NONMAGNETIC IMPURITIES IN SINGLET-TRIPLET MAGNET.

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Strongly correlated oxides as cuprates ($YBa_2Cu_3O_{6+x}$, $La_{2-x}Sr_xCuO_4$, $La_2CuO_{4+\delta}$), manganites ($La_{1-x}Sr_xMnO_3$,), bismuthates ($(K,Ba)BiO_3$, $BaBi_{1-x}Pb_xO_3$) are considered to be unstable with respect to disproportionation reaction with formation of the electron and hole centers which system appears to be equivalent to Bose-liquid. These form the system of local bosons (singlet in cuprates and bismuthates, triplet in manganites), moving in the lattice of the effective hole centers. The valent multiplet of two-hole configuration for this center in doped cuprates (CuO_4^{5-}) and bismuthates (BiO_6^{7-}) includes both the spin singlet (like $^1A_{1g}$ Zhang-Rice singlet in cuprates) state and spin triplet state [1] that implies this two-component spin system to be considered as a singlet-triplet magnet. Principal mean-field configurations of singlet-triplet magnet include non-magnetic phase with the purely singlet state of the hole center, a rather conventional spin structures with the purely triplet state of the hole center and unconventional modes with the mixed spin multiplicity.

Magnetic or nonmagnetic substitution of active cations like Cu^{2+} (for Ni^{2+} or Zn^{2+} ions) or Bi^{4+} (for Pb^{2+} ions) in singlet-triplet magnets results in unconventional magnetic reply and strongly deviates from that in conventional spin systems. In particular, non-magnetic substitution can induce local paramagnetism or even local magnetic polarization. We suggest simple microscopic models for the Ni^{2+} or Zn^{2+} substitution in cuprates and Pb^{2+} substitution in bismuthates. Within the mean-field approximation one calculates the temperature dependence of the local magnetic order parameters.

[1] A.S. Moskvin, Physica C, **282-287**, 1807 (1997); Physica B, **252**, 186 (1998).

Th-PB092

THE EFFECT OF DISORDER AND NEAREST ENVIRONMENT ON THE ORBITAL MAGNETIC MOMENT IN ALLOYS OF TRANSITION METAL AND METALLOID

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This paper deals with the behavior of the orbital magnetic moment (M_{orb}) in the most typical metal-metalloid alloys FeSi and FeSn. It is important when analyzing the hyperfine fields (HFF). The contribution to HFF due to M_{orb} is rather large and is not constant as it is usually believed. Since HFF depends on environment, the problem appears: How the impurity inclusion into the Fe environment and the alloy disordering affect the orbital magnetic moment.

The self-consistent band-structure calculations were performed using the full-potential linearized augmented plane waves (FLAPW) method with the WIEN97 program package. It was shown that the addition of impurities in environment increases M_{orb}, which agrees with the experimental differences of the total hyperfine field in disordered alloys $Fe_{1-x}Si_x$ and $Fe_{1-x}Sn_x$ [1,2]: H^0-$H^1 \approx H^1$-$H^2 \approx 25$ kG, where H^i is a hyperfine field at Fe nuclei with i metalloid impurities in nearest environment. Disordering the alloy enhances M_{orb} at Fe provided that the local spin magnetic moment keeps constant.

[1] Elsukov E.P., Konygin G.N., Barinov V.A., and Voronina E.V. // J.Phys.: Cond. Matt. 4, (1992), p.7597. [2] Elsukov E.P., Voronina E.V., Fomin V.M., and Konygin G.N. // Phys. Met. Metallogr. 85, (1998), p.307.

Th-PB093

INFLUENCE OF CARBON AND NITROGEN ON ELECTRONIC STRUCTURE AND HYPERFINE INTERACTIONS FOR FCC IRON-BASED ALLOYS

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The structural stability is a limiting factor in the development of stainless austenitic steels and a precise prediction of their phase stability is an important task of the physical metallurgy. For deep understanding of the nature of this stability, a thorough knowledge of the influence of alloying and heat treatment processes on the electronic structure of austenitic steels is needed. It is obviously interesting to study the influence of C and N atomic and electronic structure of fcc iron. That's why Fe_8C and Fe_8N alloys were chosen as objects of our studies. Our approach is based on employing widely spread FLAPW method for calculation of electronic structure, lattice relaxation and parameters of Mössbauer spectra of fcc iron with C and N interstitial impurities. Generalized gradient approximation was used for exchange-correlation potential. The calculated partial densities lead to a conclusion about higher localization degree of N 2p-states compare to C 2p-states. This leads to higher hybridization effects between Fe d-states and C p-states, which also proves the fact that chemical Fe-C bond in Fe_8C has higher covalent part. The results of our calculations show that deformation effects play an important role in the nearest-neighbor structure in the process of alloying of Fe fcc alloys by light interstitial impurities. Inhomogeneous deformation, appearing around interstitial impurity, plays significant role in structure relaxation. There is significant difference in interactions of N and C atoms with Fe fcc lattice, which leads to different relaxation degrees lattice. The calculations allow carrying out the interpretation of experimental data of Mössbauer spectroscopy for the Fe-C and Fe-N systems.

Th-PB094

NONLINEAR PROPERTIES OF SPIN-ECHO SIGNALS OF NUCLEI ARRANGED IN DOMAIN WALLS OF MAGNETICS.

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The low temperature dynamics of electron-nuclear spin-systems with a small dynamical frequency shift was investigated on the example of the so-called auxiliary echo formed by nuclei arranged in domain walls of manganese ferrite [1].

Specific properties of the auxiliary echo were experimentally investigated showing its nonlinear origin.

The synchronous change effect of magnetic and single-pulse echoes intensities in hexagonal cobalt at domain walls displacement by pulsed magnetic field [2] and the similar one for auxiliary and main echo signals in manganese ferrite speak in favor of the domain wall origin of these echo signals.

[1] A.S. Borovik-Romanov, Yu.M. Bunkov, B.S. Dumesh, M.I. Kurkin, M.P. Petrov, V.P. Chekmarev. // UFN, v.142, No4, (1984), p.537.

[2] A.M. Akhalkatsi, G.I. Mamniashvili, T.I. Sanadze. // Appl. Magn. Res. 15/3-4, (1998), p.393.

Th-PB095
DETERMINATION OF MAGNETIC FILMS THERMOPHYSYCAL PARAMETERS

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On the basis of the laser flash method (LFM) and authors know-how the new method of magnetic films thermophysical parameters determination is created. The method is based on the analysis of temperature front distribution dynamics in the examined film at exposure of film-substrate system by laser impulse. It is shown that the use of nanosecond laser impulses is most effective for a study of the films of some micron thickness, and picosecond impulses for films of more than 100 A thickness. Working breadboard model of measuring equipment which permits to conduct researches both in gas medium and in vacuum is constructed. Developed technique allows to use it for study and monitoring of films during deposition.
The method will appear to be useful for thermal laser probe scanning of magnetooptic data carriers which use new materials as a recording medium, intended to increase density of recorded information. Considering its high sensitivity the method can be also applied for monitoring of other products with covers.

Th-PB096
MAGNETIC MEASUREMENT OF Cr_3Si DOPED Fe

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Single crystalline samples of Cr_3Si doped Fe were prepared by Czochralski method. The magnetization of these samples were measured by VSM – method dependent on magnetic field (-12 kOe to 12 kOe) and temperature (10 K to 300 K). It is demonstrated that depending on the iron content, different magnetic phases are observed. With increasing iron concentration the alloy changes from the paramagnetic on to the ferromagnetic, while probably antiferromagnetic ordering is realised in the transient range of concentration (2,5 % at of Fe).

Th-PB097

MAGNETIC PROPERTIES OF PERIODIC NONUNIFORM SPIN-1/2 XX CHAINS

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We study the thermodynamic properties of the *regularly alternating* spin-1/2 XX chain in a transverse field. Using the Jordan-Wigner fermionization, the temperature double-time Green function approach, and the continued fractions we can find the exact expression for the density of magnon states for any finite period of nonuniformity. Periodic nonuniformity leads to a splitting of the magnon band into several subbands, a number of which does not exceed the period of nonuniformity. Because of this the thermodynamic quantities may exhibit a nontrivial behaviour. In particular, one observes the plateau-like dependence of transverse magnetization on transverse field at T=0. We also find that the chain with regular nonuniformity may exhibit a non-zero magnetization at the zero averaged field and an increasing of the susceptibility with increasing temperature. We extend the model assuming the transverse fields to be independent random Lorentzian variables.

Th-PB098

$L_{2,3}$-EMISSION OF MN IN HEUSLER ALLOYS FOLLOWING ENERGY-DEPENDENT EXCITATION WITH CIRCULARLY POLARIZED X-RAYS.

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$L_{2,3}$ Mn X-ray emission spectra, following the excitation with circularly polarized -X-rays, were carried out on beam-line ID12B, ESRF. The measurements have been done in external magnetic field 0.1 -0.2 T in parallel and antiparallel geometry to incident X-rays. The magnetic dichroism was detected in emisson and absorbtion spectra. The value of emission dichroism depends on excitation energy and reaches maximum at L_3 absorbtion edge and L_2 emission spectra. Maximum effect was observed for NiMnSb.
Effect of magnetic dichroism in X-ray emission indicates distinction for spin up and spin down 3d Mn DOS distribution.

It was shown, that the differences at Mn Lα and Mn Lβ magnetic spectra are linked with non-symmetry character of Mn $3d_{3/2}$ и Mn $3d_{5/2}$ DOS distribution in valence band. Sharp emission peak at Mn L3 was found. The energy position of this peak is coincided with absorption L_3 edge peak. Both peaks correspond to maximum of empty DOS Mn states.

[1] J.Stohr and Y.Wu, New directions in research with 3-d generation Soft X-Ray Synchrotron

Th-PB099
MAGNETOOPTICAL STUDIES OF THE JAHN-TELLER ELASTIC $CsDy(MoO_4)_2$

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The strong coupling between electron subsystem and crystal lattice in the Jahn-Teller crystals makes it possible the influence on the crystal lattice by affecting electron subsystem. The double molybdate crystals belong to the group of compounds in which the structure phase transitions of the cooperative Jahn-Teller effect (CJTE) type are observed at low temperatures. In the crystal $CsDy(MoO_4)_2$ the structural phase transition of CJTE type occurs at T~40K. The characteristic feature of this compound is the antiferrodistortion kind of ordering. There are the experimental evidences [1] that in such materials the structural phase transformations are possible under action of magnetic field. In contrast to compounds studied earlier, in $CsDy(MoO_4)_2$ the phase transition induced by magnetic field must result in domain structure origination and magnetostriction with rather significant value. This phenomenon may be important from the application point of view.
With the aim of revealing of the possible phase transformations induced by magnetic field in the crystal $CsDy(MoO_4)_2$ the magnetooptical measurements of the absorption spectra in the region of electron transition $^6H_{15/2}$-$^6F_{3/2}$ in Dy^{3+} ion were carried out. The values of g-factors of the spectroscopy splitting of the ground state of Dy^{3+} ion were found out. The experimental results allowed the definite conclusion about probable structure transitions induced by magnetic field and orientation of magnetic field at which the phase transition is possible in $CsDy(MoO_4)_2$.

1.M.J.M. Leask, A.C.Tropper and M.R.Weeler, J.Phys.C, 1981, 14 , No.24, 3481-3498.

Th-PB100
AN UNUSUAL LONG MAGNETIC RELAXATION TIME IN Fe-Bi FILMS

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Recently a time-dependent behavior of electrical resistivity has been observed in Fe-Bi films. The dependence on time of electrical resistivity follows the equation $R(t) = R_s - Ae^{-t/\tau}$ with the characteristic time $\tau = 23.2$ hours at room temperature. However, at 77K, the electrical resistivity is almost unchanged with time. The increasing of electrical resistivity is accompanied with an increasing magnetization and it can be depressed by increasing applied magnetic field. From *X*-ray diffraction, it has been found that the film contains metastable Fe-Bi alloys with rhombohedral structure. The long magnetic relaxation time is believed to be associated with large Fermi wavelength of the semi-metallic Bi [1]. The detailed explanation of the mechanism, which causes this unusual behavior, will be reported in this work.

[1] Garcia N., Kao Y. H., and Strongin M.// Phys. Rev. B5, (1972), p. 2029.

Th-PB101

MAGNETIC DOMAIN WIDTH AND WALL MOBILITY ESTIMATED FROM MAGNETOMECHANICAL DAMPING

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The logarithmic decrement δ, which is a measure of the eddy current losses due to domain wall motion, and ΔE-effect were measured simultaneously for 30~42%Fe-Ni alloy system in kHz range of flexural vibrations, as a function of temperature and magnetic fields. The logarithmic decrement and ΔE-effect are given respectively as $\delta=\Delta_M\omega\tau/(1+\omega^2\tau^2)$ and $\Delta E/E=\Delta_M/(1+\omega^2\tau^2)$, where Δ_M is the relaxation strength, τ is the relaxation time and ω is the measuring frequency [1]. $(\Delta E/E)/\delta$ gives an experimental value of τ and then we obtain Δ_M. τ is ratio of the damping coefficient β to stiffness constant α for domain wall oscillation and expressed by square of the mean domain width, initial susceptibility etc. On the other hand, Δ_M is expressed by saturation magnetization, magnetostriction, Young's modulus etc.

Using these magnetic experimental values we are going to report the average domain width as a function of magnetization and temperature, temperature dependence of the damping coefficient β and the mobility constant ξ connecting to the velocity of wall motion.

[1]W.P.MASON// Rev. Mod. Phys. 25(1953)36
[2]T.Maeda//Proc. 2nd Int. Sym. Phys. Mag. Mater. (Beijin, 1992) p.105

Th-PB102

RELATION OF MAGNETIC AND STRUCTURE FACTORS AT PHASE TRANSITIONS IN MAGNETICS

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On the basis of results which were obtained in the process of our numerous comprehensive studies as to temperature, high pressure and high magnetic field influence upon phase conditions of magnetic materials a number of characteristic properties of phase transition passing because of connection of their magnetic and crystallochemical characteristics is established.

The main role of competitive interaction of magnetic and structural order parameter and also influence of magnetostriction blocking and plastic unblocking of nucleation processes in forming of unique magnetic phase first-order transition – ferromagnetic order – paramagnetic disorder is shown for alloys on manganese-arsenide base.

Connections between magnetic and structural transitions, crystal symmetry and energetic condition of magnetoactive atoms are established for fluorosilicate hexahydrate salts of 3d transition metals.

The ability to form the metastable conditions due to magnetostriction connection between magnetic ordering property and interatomic distances in crystal is revealed in alloys on iron-rhodium base.

The general rules in magnetic materials behavior in extreme conditions caused by simultaneous change of crystal lattice symmetry and ordering property in crystal are established. The opportunities of application of magnetic structural connection for magnetic material properties control are considered.

Th-PB103

THE TRANSVERSE DYNAMIC STRUCTURE FACTOR FOR ISING MODEL WITH DIFFERENT RANGES OF INTERACTION

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The shape of the transverse dynamic structure factor for spin-1/2 Ising model is investigated within the effective field method. We extend the correlated effective field approximation to the Ising model with arbitrary range of interaction. Starting from the Callen identity, one can express the thermodynamic functions of the model through the local field distribution function $P(h) = \langle \delta(h - h_k) \rangle$ where $h_k = \sum_{j \neq k} J(R_{kj}) S_j^z$ is field which acts on the spin on site *k*. Besides, the transverse dynamic structure factor can be obtained using *P(h)*:

$$\tfrac{1}{2\pi} \int_{-\infty}^{\infty} dt \exp(-i\omega t) \sum_{ij} \exp(ikR_{ij}) \langle S_i^x S_j^x(t) \rangle = \frac{P(\omega/2) + P(-\omega/2)}{1 + \exp(-\beta\omega)} .$$

In contrast to other approximations the effective field method allows to study how the shape of the transverse dynamic structure factor changes for the models with different interaction ranges. We show that this shape alters from the gaussian-like one for the model with long-range interaction to the set of peaks with finite width for the model with short-range interaction. The results of approximation leads to exact at high temperatures.

Th-PB104

INVESTIGATION OF XXZ-MODEL WITH SPIN 1/2 WITHIN TWO-PARTICLE CLUSTER APPROXIMATION

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The XXZ-model defined by Hamiltonian

$$H = -\sum_i \left(\Gamma^z S_i^z + \Gamma^x S_i^x \right) - \frac{1}{2} \sum_{i,\delta} \left[K S_i^z S_{i+\delta}^z + \alpha K \left(S_i^x S_{i+\delta}^x + S_i^y S_{i+\delta}^y \right) \right] -$$
$$- \frac{1}{2} \sum_{i,j} \left[J S_i^z S_j^z + \alpha J \left(S_i^x S_j^x + S_i^y S_j^y \right) \right]$$

was investigated within two-particle cluster approximation with two variational parameters φ^z, φ^x. The long-range interaction J was taken into account in the framework of mean-field approximation. The numerical investigation of free energy showed that at $0 \le \alpha < 1$, $\Gamma^z = \Gamma^x = 0$ and at $\alpha = 1$, $\Gamma^x = 0$, $\Gamma^z \to 0$ $\varphi^x = \langle S^x \rangle = 0$. At $\alpha > 1$, $\Gamma \ = \Gamma^x = 0$ and at $\alpha = 1$, $\Gamma^z = 0$, $\Gamma^x \to 0$ $\varphi^z = \langle S^z \rangle = 0$.

The phase diagrams were constructed and the temperature dependences of the thermodynamical characteristics were calculated for different lattices at various values of the model parameters α, J ($\Gamma^z = \Gamma \ = 0$). It was shown that at $\alpha \ge 1$ two-particle cluster approximation gave qualitatively incorrect results in a low-temperature region. The correlation functions $\langle S_{\mathbf{q}}^x S_{-\mathbf{q}}^x \rangle$ and $\langle S_0^x S_{\mathbf{n}}^x \rangle$ were calculated in the case $0 \le \alpha \le 1$, $J = 0$, $\Gamma^z = \Gamma \ = 0$.

Th-PB105

DYNAMICAL MICROMAGNETIC CALCULATION OF MAGNETIC RELAXATION OF PARTICLES

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Recently some interesting behaviors of ultra-fine particles were reported. Especially, the high density magnetic recording requires not only the ultra fine particles but also the ultra-narrow pulse. Since the relaxation time of the magnetization is comparable to the pulse width of the field, alternating switching behavior was reported below the static switching threshold. Therefore, the dynamic micromagnetics calculation is necessary to study the response of magnetic materials,

We use Landau-Lifschitz equation to develop a numerical dynamic procedure to study the behavior in magnetic system. Particles with several different aspect ratio are presented. Each particle is divided with the uniform cube and relaxation properties of the particle was studied. Instead of the conventional approximation of dipolar interaction among the cube, magnetostatic energy between the cube was exactly calculated. The particle is saturated at a large field and then relax under different small positive bias field. The magnetic relaxation curve are quite particle-shape dependent and can not fitted with a single relaxation constant of the exponential decay. However, if we consider the relaxation of magnetization energy, the exponential decay was observed. It also should noted that the magnetization at the center of the particle behave as a backbone, it resist the relaxation of the magnetization. Relaxation of hollow particles have been also studied and the relaxation time is much faster than the solid particle.

Th-PB106

STRUCTURE OF DOMAIN WALLS IN (111) PLATES OF CUBIC FERROMAGNETS

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The structure and energy of 180^0 domain walls and their orientation with respect to the crystallographic axes are investigated in a (111) plate of a cubic crystalline ferromagnet (K_1) with an induced uniaxial (K_U) anisotropy. Numerical calculations indicate to an existence of a strong dependence of domain walls (DW) structure and orientation upon material quality factor $Q=K_U/2\pi M^2$ and upon ratio $\kappa_1=K_1/K_U$ of the cubic and induced uniaxial anisotropy constants. The energy of the DW with a rotation of magnetization **M** in the domain wall plane (the Bloch-type DW) may turn out to be both greater or smaller than that of the DW with **M** deviating from the DW plane (the quasi-Bloch DW).

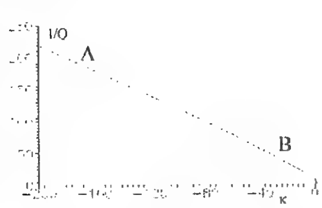

Figure present a Q^{-1} - κ_1 diagram of domain wall states. Above the AB line, energetically advantageous is the Bloch-type wall parallel to the {110} plane, whereas below the said line - the quasi-Bloch domain wall parallel to the {211} plane.

The deviation of **M** from the DW plane results from the cubic magnetic crystallographic anisotropy, i.e. from the spatial alignment of easy magnetization axes of a <111> cubic crystal. The maximum angle of **M** deviation from the quasi-Bloch wall plane is less than 30°, and at $Q\rightarrow\infty$ it approaches the greatest value, which, for instance, at $\kappa_1=200$, reaches 26°. With quality factor decreasing, the angle of magnetization deviation from the DW plane decreases, which is brought about by a rise in magnetostatic energy.

Th-PB107

SUBSURFACE AND DOUBLE VOLUME-SUBSURFACE POINT STRUCTURAL ELEMENTS IN HALF-INFINITE ISOTROPIC MAGNET.

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The problem considered is a logical consequent of refs [1,2] and is dedicated to the analysis of a capability of magnetostatic induction of point structural elements in a half-infinite isotropic magnet. Two minimum of a magnetic stray field energy corresponds to a field of a magnetization with equal zero value normal to a surface of a component of vector magnetization on all surface of a magnet, excepting singular points. At such boundary conditions the solutions for structural single subsurface singularities in the form "half-hedgehog" are obtained. The structure of their cores can be similar to "magnetization swirls" [3] or to be indefinite (in this case they are true singularities).
If at a volume of a magnetic there is a Bloch point, at a relaxation its field of a magnetization the subsurface point element is induced. Together they will form a double volume-subsurface structural element. The solutions for such structural elements are obtained.
The topological properties, problem of stability of these elements, capabilities of their experimental observation and connection with present experimental data [1,2] are considered.

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Th-PB108

NON UNIFORM EQUILIBRIUM MICROMAGNETIC STRUCTURES IN SMALL ELLIPSOIDAL PARTICLES

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In real recording media, a distribution of particle sizes occur so there is always a certain fraction of particles present that exceed the critical size for truly single domain behaviour. There is thus considerable motivation for studying the micromagnetics of mesoscopic particles whose magnetization is intermediate between single- and multi- domain.
We report the numerical simulation of nonuniform magnetization distributions in prolate ellipsoidal particles having aspect ratios in the range of $1.5 \le L_z/D \le 4.5$. The particle diameters studied were within the range of $60 \le D \le 200$ nm. The material parameters of the particles investigated covered the range: saturation magnetization $M_s = 550 \div 800$ G; exchange constant $A = 0.5 \cdot 10^{-6}$ erg/cm; and anisotropy constant $K_1 = 10^4 \div 10^5$ erg/cm^3. Different types of magnetization configurations are revealed, the uniform state and the longitudinal and transverse curling states. The single-domain radius as function of particle aspect ratio and material parameters is obtained. Comparison with the Brown's upper and lower bound estimates [1] is made. The range for stability of the longitudinal curling state, lying intermediate between the flower and transverse curling state, is established.
This work was supported in part by means of INTAS grant #97-31311.
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Th-PB109

EQUATION OF THE DOMAIN WALL MOTION IN CASE OF EMF MATTEUCCI APPEARS

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In this work in the equation of the domain wall motion in magnetic sandwich structure [1] we take into account the eddy current field $H_{e.c.\perp}$ caused by the transversal component of the magnetization of the ribbon with helical magnetic anisotropy [2]. The found equation doesn't contain the derivative $dx/d\tau$, where $x(\tau)$ is the distance of the domain wall from the middle of ribbon. Owing to this the found equation has the numerical solution for $x(\tau)$ (when the coefficient of friction β_r is known) or for $\beta_r(x)$ (when $x(\tau)$ is known) after we had made substitution in it the experimental values of the applied field $H_a(\tau)$, emf of the induction coil $E_B(\tau)$ and emf Matteucci $E_M(\tau)$. The equation contains the empirical coefficient k for coordination the experimental value $dx/d\tau$ with the experimental values $E_B(\tau)$ and $E_M(\tau)$. $x(\tau)$ may be found from the independent equation $x^2 \sim (E_M/E_B)$ [2]. Thus we found $\beta_r(x)$.
Measurement was made on amorphous ribbon $Co_{68}Fe_4Cr_4Si_{13}B_{11}$ with helical magnetic anisotropy [2] (H_m=.17 A/m, f = 1 kHz). For values 1< x <6 μm and x >8 μm, where $dx/d\tau \approx 0,1$ m/s, β_r is ~10^2 kg/m²·s, k<1. For values 6< x <8, where $dx/d\tau \approx 0,01$ m/s, β_r is ~10^3 kg/m²·s, k>1.

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Th-PB110

EPR-SPECTRUM OF POLYANILINE DOPED BY $K_3Fe(CN)_6$

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Effect of unusual temperature change in EPR-spectrum of polyaniline doped by $[Fe(CN)_6]^{3-}$ has been detected Spectrum of powder polyaniline is the sum of three lines: free radicals of polymer (g_3 = 2,00 ±0,01) and EPR-signal of $Fe^{(III)}$ ion which is the superposition of low-temperature (LT), $g_1 = 4.22 \pm 0.03$, and high-temperature (HT) spectra, $g_2 = 2.13 \pm 0.05$.The value of g_1 is corresponded to magnetic center of ion $Fe^{(III)}$, which low-symmetrical component of "crystalline" field is more larger than Zeemane energy, and g_2 is due to magnetic center of ion, which low-symmetrical component is significantly less than Zeemane energy. At low temperatures the neighbor surrounding of $Fe^{(III)}$ ion has a strong distorted, but at high temperatures the $[Fe(CN)_6]^{3-}$ complex is near to right octahedron. Process of transition from LT to HT spectrum is occurred gradually and accompanied by redistribution of absorption intensity. Such EPR temperature dependence is attributed to systems with multiminimum potential. The $Fe^{(III)}$ ion acts as paramagnetic sound, allowing to observe the unusual dynamic of molecular surrounding which consists of the aromatic fragments.

Th-PB111

MAGNETIC VISCOSITY IN THE ORGANIC ANTIFERROMAGNET $Mn^{II}(hfac)2$ WITH ONE-DIMENTIONAL CHAIN STRUCTURE

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The kinetics of the metamagnetic phase transition in manganese (II) bis (hexafluoroacetilacetonate), $Mn^{II}(hfac)_2$, has been studied using the ac susceptibility and the pulse field magnetization measurements. $Mn^{II}(hfac)_2$ crystallizes in the monoclinic structure which is formed by one-dimensional polymeric chains [1]. At decreasing temperature below T_N = 5.5 K this compound becomes an antiferromagnet (AF) owing to the antiparallel alignment of the magnetization of ferrimagnetically ordered chains. At $T< T_N$ a small magnetic field (0.02-0.04 T) applied along the *c*-axis induces the first order magnetic phase transition from the AF to the ferrimagnetic (FI) state. This transition results from a very low ratio between the interchain (J') and intrachain (J) exchange interactions ($|J'|/J\approx10^{-3}$). The strong frequency dependence of the ac -susceptibility and the enhanced value of its imaginary part in vicinity of the AF-FI transition have been observed. In pulse fields an increase of the critical transition field up to about 0.1 T and remnant magnetization were detected. The last disappears within the time of about 0.5 s. The peculiarities of the magnetization process in $Mn^{II}(hfac)_2$ are likely to be associated with the slow dynamic switching of the magnetization of chains at the domain wall motion in the intermediate state where both the AF and FI phases coexist.

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Th-PB112

FIELD INDUCED PHASE TRANSITIONS IN A PRUSSIAN BLUE ANALOG MAGNET EXHIBITING TWO COMPENSATION TEMPERATURES.

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The phase transitions in a novel magnet $(Ni_aMn_bFe_{1-a-b})_{1.5}[Cr(CN)_6]$ with two compensation temperatures are theoretically investigated. Established strong (sharp) dependence of compensation temperatures from chemical compound. For the first time H-T phase diagram are build for the various Prussian blue analog compounds with two compensation points. Some of these compounds looks like an antiferromagnet in the rather wide temperature interval.

Th-PB113

SPECIFIC HEAT AND MAGNETIC INTERACTIONS IN SPIN LADDER RARE-EARTH AND TRANSITION METAL-BASED MOLECULAR MAGNETS

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The compounds $R_2[Cu(opba)]_3{\cdot}S$ (where opba stands for *ortho*-phenylenebis(oxamato) and S for solvent molecules) with R=Ho, Dy are spin-ladder based molecular magnets. Low temperature specific heat measurements show that both compounds undergo three-dimensional magnetic ordering with T_c = 0.20 K and T_c = 0.74 K for the Ho and the Dy containing compounds, respectively. These results are compared with the magnetic properties of the isostructural $Gd_2[Cu(opba)]_3{\cdot}S$, that is a ferromagnet [1], and $Gd_2[Zn(opba)]_3{\cdot}S$. The role of dipolar interactions, that drive these low dimensional systems to 3D order, is discussed.

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Th-PB114

AB-INITIO CALCULATIONS OF THE ELECTRON STRUCTURE AND ENERGY LEVELS OF THE Co^{2+}-OROTATE COMPLEX.

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The investigations of the magnetic properties of cobalt containing biological compounds (for example, cobalt-carboanhydrase enzymes [1] or complexes of cobalt with nucleic acids [2]) are of great interest. The main goal of such investigations is the determination of coordination sphere structures and 3d-electronic level splitting in the zero magnetic field. The interpretation of the experimental data from the biochemical point of view usually is very difficult and requires employment of results of the theoretical calculations.
In this work we carried out the *ab-initio* calculations of the electronic structure of the orotic acid-Co^{2+}-$3H_2O$ complex at the HF/6-31G* level of theory. In the calculations we used the experimentally determined geometry of the complex. The calculated data are compared with the experimental values of the g-factors of the Co^{2+} ion [3].

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Th-PB115

IMMOBILIZATION OF PROTEINS, ENZYMES AND DRUGS TO FINE MAGNETIC PARTICLES

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In a recent study [1] it was found that Bovine Serum Albumin can be covalently bound to magnetic particles. In an extension of this study we have immobilized several clinically important proteins, enzymes and drugs (BSA, Dispase, Chymotrypsin, Streptokinase and 5 – Fluorouracil) and found that their biological activity was retained, up to 90% in certain case. Magnetic measurements, protein and enzyme assays, electron microscopy and FTIR spectra confirmed the binding of proteins, enzymes and drugs to freshly prepared magnetic particles. We discuss in this paper the potential applications of direct binding procedure in drug targeting in coronary and peripheral vascoocclusive diseases for clot lysis, in localized chemotherapy and in biotechnology.

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Th-PB116

RESONANCE INFLUENCE OF ALTERNATING MAGNETIC FIELDS ON IONIC PERMEABILITY OF CELL MEMBRANES

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One of the main targets of magnetic fields' influence on a living organism is the system of cell membranes. Although there were many attempts to explain the mechanism of this influence, there is no unique model for it so far. In this work a possible mechanism of influence of low-frequency alternating magnetic fields on permeability of membranes is suggested.

A membrane is considered as an energy barrier for ions. An ion in a membrane can be, under appropriate condition, in a bound state. The ion may have one-dimensional oscillations around the bound state; the direction of oscillations is perpendicular to the membrane plane. An alternating external magnetic field in the membrane plane causes a parametric influence on the ion's motion. For certain values of the frequency and the amplitude of the magnetic field this leads to a substantial increase of the amplitude of ion's oscillations (parametric resonance) and, thus, to an increase of permeability of the cell membrane. This model is used to write the equations describing ion's motion in the membrane. In the framework of the perturbation theory for small amplitudes of the magnetic field, the boundaries of the domains of parametric increase of ionic permeability in the amplitude-frequency plane of the external magnetic field are obtained.

Th-PB117
A MAGNETIC ANISOTROPY OF ORGANIC MOLECULES

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The alignment of organic molecules in magnetic fields was investigated. A degree of the sample orientation was estimated microscopically. Magnetic anisotropy of oriented probes of fibrin and molecules included iron atoms (hemin, hemoglobin and methemoglobin) were carried out with a torsion magnetometer in temperature 75K and 295K in magnetic field up to 1.6 T.
All examined molecules show an uniaxial anisotropy. Magnetic induced anisotropy for fibrin can be explained by diamagnetic shape anisotropy due to rod-like molecule enhancement by polymerization into chains and small elongated groups.
The value of effective anisotropy constant obtained for hemin is higher than in methemoglobin and hemoglobin. An intrinsic magnetic anisotropy of these samples depends on spin state of Fe ion. However the clarification of high induced anisotropy obtained experimentally is possible by taking into consideration a shape anisotropy connected with a tendency of molecules to aggregate into chains.
Magnetic field used for samples orientation (2T and 8T) did not have an essential influence on degree of orientation when the number of molecules in investigated sample is high.

Th-PB118
CONTROL OF THE CRYSTALLOGRAPHIC TEXTURE PARAMETERS OF ELECTRICAL SHEET STEEL BY THE BARKHAUSEN JUMPS FLUX

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A study of the dependence of the angular dispersion γ for the crystall grain turn relative to (110) direction, which is one of the parameters of the texture perfectness degree [1],on electromotive force (EMF) averaged over a period of the Barkhausen jumps (BJ) flux is performed in a coldrolled anisotropic electrical sheet steel. The grains tested were electropolished and the angle γ of a turn relative to the transverse direction (110) was determined by method of the combined X-ray magnetic topography with an accuracy of $\sim 0.5^{O}$. The lay-on sensor was set on an individual grain so that the magnetizing field was oriented along easy magnetization axis [001] coinciding with the rolling direction of the case .
The studies showed a good correlation between the value of angular deflection of the crystal grain face relative to the transverse direction [110] and EMF of the BG flux averaged over a period. The correlation found may be explained by that the BJ flux parameters are the structure-sensitive magnetic characteristics.
In this work, a distinct connection between the value of angular deflection of the faces (110) of individual grains from a rolling plane and the EMF of the BG flux averaged over a period is shown.

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Th-PB119

PORTABLE THREE COMPONENT MAGNETOMETER WITH TINY SENSORS WHICH ARE BASED ON MAGNETIC COMPARATOR MADE OF BISTABLE FERROMAGNETIC

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Magnetometer for vector modulus measurement and small magnetic fields intensity projections was worked out. This device can be used

- for the control of the inner shielding degree from earth magnetic field and other sources;
- as electronic compass;
- for medical research work;
- for magnetic fields control at the working places.

It is possible to set up gauge for measuring low frequency ac fields intensity generated by industrial devices, electrical network, electrical appliances.

Th-PB120

Withdrawn

Th-PB121
SQUID-MAGNETOMETER FOR STUDY OF PRESSURE EFFECT ON MAGNETIC SUSCEPTIBILITY OF SOLIDS

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A simple method for measuring the effect of hydrostatic pressure on the magnetic susceptibility in solids is described. Traditionally, when employing a SQUID devices with this aim in mind, an autonomous pressure cell is used and the magnitude of total magnetic moment of a sample plus cell is measured at fixed pressure. Some disadvantages of the method mentioned are a non-uniformity of pressure and relatively large error of the moment measurements. Owing to latter the high enough pressures have to be used to detect the pressure effect with reasonable accuracy.
In the present method the cell is connected with a gaseous compressor by capillary. This arrangement makes it possible to measure *the change* of magnetic moment as the pressure applies. In order to eliminate a possible change of the moment due to the temperature variations under pressure, the latter is applied in a stepwise manner followed by exposure after each step sufficient to return the system to its original state. To reduce the relaxation time, the cryogenic liquids were used for thermosetting the pressure cell at fixed temperatures, namely, 4.2, 20.4 and 77.3 K. As a result, an accuracy of the measurements increases essentially and the pressure effect can be detected at low pressures of order of 100 bar. The test measurements of the effect of pressure up to 150 bar on the magnetic susceptibility of the reference samples of the intermetallic compounds MnSi, $YbAgCu_4$ and $YbInCu_4$ give evidence for the validity of the method for the pressure effects study. Because of the availability of application of a low pressure we can realize a pure hydrostatic regime at 4.2 K.

Th-PB122
MAGNETIC SENSING CIRCUITS IN MAGNETODEFECTOSCOPY

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Magnetic method known as the magnetic defectoscopy has presently been recognized as the objective way in the frame of steel rope inspection [1]. This method allows us to detect not only the surface breakages, but also the internal defects. The basic part of the magnetic defectoscope is a measuring head with optoelectronic incremental element. Inside of the measuring head are located sensing circuits. One of them is designed for the breakage defects, the other one is constructed for corrosion level specification. The paper is intended to sensing circuit geometry effect in magnetic defectoscope. The correlations between axial and radial defect geometry and sensing circuit configuration are analyzed in detail.
In the first the problem is solved by ANSYS software. There are the special defects (f. e. cracks) where the air gaps are in longitudinal direction less than 1 mm. In these cases is problematic to realize the magnetic inspection with help of two channels (corrosion channel and breakage one). The detection unit has been divided into three parts. The third sensing circuit (crack one) is concentrated on microdefects.
In the second step the experimental setup is used to demonstrate the axial distance influence of the magnetic sensing circuits on the sensibility and signal output.

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Th-PB123

INVESTIGATION OF MAGNETIC AFTEREFFECT IN THIN MAGNETIC FILMS BY USING STM

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Method of the investigation of magnetic aftereffect (magnetic viscosity, disaccomodation), hysteresis in the thin magnet films with domain struture by using scanning tunel microscop (STM) is elaborate.

The dependences of the relaxation time of amplitude and external magnetic field's frequency are obtained for bubble garnet films with thickness 3-5 mk. The relaxation time of domain structure for these samples is approximately 40 sec in the absence of the external alternating magnet field. The relaxation time tends to zero at the change of external alternating magnet field's amplitude. The field with 100 Hz is oriented along the easy axis and changed from 0 to the coercitivity field (1 Oe).

Results of the experiments are interpreted in frame of the fluctuation aftereffect theory [1].

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Th-PB124

MULTIQUANTUM EFFECTS AND SPIN ECHOES OF QUADRUPOLAR NUCLEI WITH SPIN $I=5/2$ IN MAGNETICALLY ORDERED SUBSTANCES

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The multiple structure and relaxation of NMR two-pulse echo signals of nuclei with spin $I=5/2$ (nuclei ^{55}Mn) in magnetically ordered substances have been studied.

It has been shown that all $2I=5$ lines of the NMR spectrum $V_{2\tau}(\nu)$ may be obtain only with help of Hahn echo observed at $t=2\tau$. The NMR spectrum $V_{6\tau}(\nu)$ obtained with help of multiquantum echo signal observed at $t=6\tau$ contains only one spectral line at frequency defined by hyperfine magnetic interaction (spectral transition $\pm 1/2 \leftrightarrow \mp 1/2$). The NMR spectrum $V_{4\tau}(\nu)$ contain three lines (spectral transitions $\pm 1/2 \leftrightarrow \mp 1/2$ and $\pm 3/2 \leftrightarrow \pm 1/2$). The relaxation of the quadrupolar spin echoes at $t=2\tau,\ 4\tau,\ 6\tau$ has been discussed under assumption that the relaxation is determined by the random fluctuations of the electron magnetization orientation [1-4].

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Th-PB125

A METHOD FOR EXPERIMENTAL EVALUATION OF WEIGHT OF POWER LOSS DUE TO SINGLE HARMONICS IN A FERROMAGNET AT NONHARMONIC FLUX DENSITY

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The method is based on the assumption that an inductor with the core made from ferromagnetic material, for which the specific losses at harmonic magnetisation rise with amplitude of flux density as $P \sim B_m{}^n$, where n is close to 2, can be considered as a linear device.
It can then be supposed that once the $(2k+1)^{\text{th}}$ harmonic is eliminated in the driving voltage waveform $v(t)$, the flux density waveform $B(t)$ does not contain the $(2k+1)^{\text{th}}$ harmonic component as well.
The specific power loss due to $(2k+1)^{\text{th}}$ harmonic can then be determined as a difference of two values of power loss measured at given driving voltage waveform, e.g. symmetrical rectangular one $v_{Sq}(t)$ and then at $v(t) = v_{Sq}(t) - \dfrac{4V_m}{\pi(2k+1)} \cdot \sin(2k+1)\omega_1 t$.

Th-PB126

Withdrawn

Th-PB127

METHOD FOR OBSERVATION OF DOMAIN STRUCTURE IN AMORPHOUS MICROWIRES WITH A CIRCULAR ANISOTROPY.

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On a base of nondiagonal magnetoimpedance [1] a simple and effective method of observation of an axial component of a magnetization in amorphous microwires with a circular anisotropy is proposed. We use the short pick-up coil (0,2 mm in length and 0,5 mm in diameter) wounded around the wire and move it along the sample, which is excited by an ac current in a small magnetic field. In areas with an opposite sign of magnetization the phase of the signal in the coil differs by π, and zero signal corresponds to position of the domain wall. Such a method allows also the observation of heterogeneity of a magnetization in the wire since the amplitude of measured signal depends on the magnetization value. As an example, fig.1 demonstrates the existence of several domains separated by domain walls.

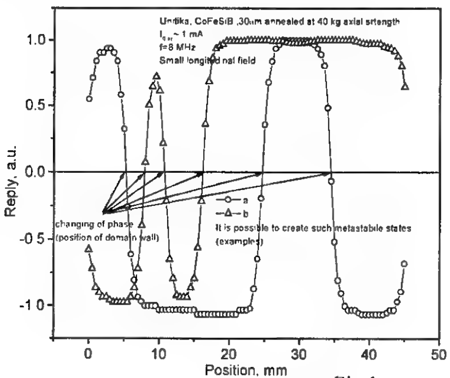

Fig.1

The work is supported by ISTC under Grant 766-98.

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Th-PB128

HYBRID CONTROL USED TO OBTAIN SINUSOIDAL CURVE FORM FOR THE POWER LOSS MEASUREMENT ON MAGNETIC MATERIALS

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Distribution of electrical power is principally associated with sinusoidal voltage. As the magnetic circuits are strongly non-linear, it is not sufficient for the measurement to excite the primary winding by applying a sinusoidal voltage source. In order to achieve comparable results the measurements of specific power loss should be carried out in accordance with the IEC 60404-2 and IEC 60404-3 standards, i.e. the form factor of the secondary voltage should not deviate by more than 1 % from that of a sinusoidal voltage. Today this can normally be achieved by analogue control, however digital controls, too, are applied to an increasing extent. Both methods offer various advantages and disadvantages. This paper presents a hybrid control combining the analogue and digital controls with the advantages of both of them. At low polarization the hybrid control works like the analogue one. The distortions which cannot be compensated at high polarization values by the analogue feedback are suppressed by the digital control component, using controlled pre-distortion of compensating character.
The distortion factor of the secondary voltage at high polarization can be reduced to about 50 % compared with an analogue feedback alone, and this is achieved with fewer iterations than in the case of the pure digital control.

Th-PB129

FOURIER ANALYSIS OF THE STRIPE DOMAIN STRUCTURE IMAGE

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Epitaxial iron garnet films of (111) orientation having moderate uniaxial anisotropy demonstrate usually the stripe domain structure (SDS) [1]. Its configuration is determined by cubic anisotropy that orients stripes along easy magnetization axis of the <112> type and causes a small deviation of domains' magnetization from the film plane. The work is devoted to analysis of the SDS parameters determination method by means of Fourier analysis of the SDS image observed in usual Faraday geometry. The SDS is considered as areas of uniform magnetization with sharp boundaries oriented in {110} plane. Parameters describing the SDS are: the normal component of local domains' magnetization and domains' wide. In the <110> direction the SDS may be presented as the one-dimensional function of local magnetization having a shape of meander line. The Fourier spectrum of this function consists of discrete harmonics. The SDS period is determined from position of harmonics. All other parameters of SDS may be deduced from intensities of Fourier harmonics. The proposed procedure may be used for local domain magnetization determination during magnetization reversal of iron garnet films with inclined magnetization in domains. The requirements for SDS image registration and conditions of parameters determination by means of discrete Fourier transformation as well as its acuracy are studied using image processing simulation and obtained results are discussed.

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Th-PB130

LOW-FREQUENCY MAGNETIC HINDRANCE METER OPERATING BETWEEN THE INDUSTRIAL NETWORK FREQUENCY HARMONICS

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The intensive development of industry as one of its consequences has lead to the increase of the magnetic field induction within the urban area as compared to the natural background. This results in deterioration of an accuracy of electrical and magnetic measurements, as well as in worthening of the working conditions for metal-detecting and nondestructive testing devices.
The special magnetometer was designed for measurement and control of the environmental pollution by the sound-frequency magnetic fields, except of the industrial network (50 Hz) frequency and its harmonic. The measurements can be carried out on frequencies 85, 171, 341, 683, 1365, 2730 and 5460 Hz in the bandwidth 1 Hz within the limits 5, 10, 20, 50, 100, 200, 500 and 1000 picotesla (1 picotesla = 10^{-12} tesla) with an opportunity of each limit expansion in 100 times. Indication is performed in an analog manner by the arrow device. The accuracy of measurements - 20 %. The dimensions of the induction converter: diameter - 110 mm; thickness - 42 mm. Dimensions of the electronic block: 210 x 140 x 130 mm. The device is battery operated.
The operation principle of the device is in the measurement of beats amplitude, arising in the lock-in detector between the magnetic field induced voltage from the induction converter and the reference voltage of the fixed frequency, that is produced by the built - in quartz generator.

Th-PB131

MAGNETIC PROPERTIES OF ITTRIYM IRON GARNET FILMS

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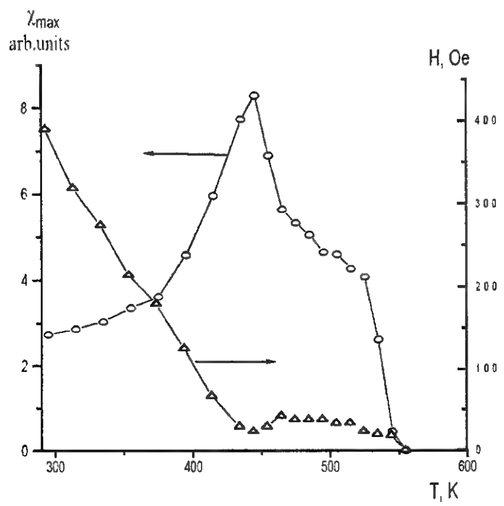
The apparatus for measuring of differential magnetic susceptibility of film structures under the raised temperatures was elaborated using offered in [1] method.The tests were performed on the yttrium iron garnet epitaxial films by 2.82 μm thickness with orientation <111>. Range of temperature measurements - from room to Curie temperature. Temperature dependence of maximum value of susceptibility and external magnetic field, when it is observed, is shown in the figure. The obtained value of Curie temperature is of about 540K and correlated with literature data. Apparatus sensitivity on the samples with 1cm^2 area allows to make the measurement on films by thickness to 0.1 μm with good reproduction results.



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Th-PB132

REGULARLY ALTERNATING SPIN-1/2 TRANSVERSE ISING CHAIN: RIGOROUS RESULTS FOR THE MAGNETIC PROPERTIES

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We consider the spin-1/2 transverse Ising chain with the Hamiltonian

$$H=\sum_{j=1}^{N}\Omega_j s_j^z+2\sum_{j=1}^{N}I_j s_j^x s_{j+1}^x$$

where the transverse field at site Ω_j and the intersite coupling $2I_j$ vary regularly from site to site, i.e. the sequence of parameters $\Omega_1 I_1 \ldots \Omega_p I_p \Omega_1 I_1 \ldots \Omega_p I_p \ldots$ is assumed. The continued fractions approach permits one to calculate exactly the density of states, $R(E^2)=(1/N)\sum_{n=1}^{N}\delta(E^2-\Lambda_n^2)$, Λ_n is the elementary excitation energy, for any finite p. As a result one is able to study rigorously the thermodynamic properties that follow from the Helmholtz free energy per site $f=-(2/\beta)\int_0^\infty dEER(E^2)\ln((2\cosh(\beta E/2))$. In the present report we compare the properties of the transverse Ising chain with such properties of the transverse XX chain that have been examined recently [1]. We analyze the low-temperature dependences of the transverse magnetization and static transverse susceptibility on the transverse field.

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Th-PB133

OVERCRITICAL MOTION OF DOMAIN WALL IN AN EXTERNAL MAGNETIC FIELD

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The dynamics of domain wall (DW) in ultra-thin ferromagnetic films in external magnetic field. It is shown that two phases of the domain wall motion are possible depending on the external magnetic field. Within the first phase (pre-critical), when magnetic field is under the critical value $h < h_c$, the angle between a magnetic moment and DW plane increases with the magnetic field growth, as well as wall velocity is increased: $V \sim h/\lambda$ (λ-dissipative constant). In the point $h = h_c$, the maximum of velocity is attained, known as critical Walker velocity, and further it becomes less dependable from the wall velocity. The second phase ($h > h_c$) is characterized by onset of low-frequency oscillations, which frequency in the beginning grow fast for $h > h_c$, then slowly decreases and makes vanish when $h \to \infty$. These oscillations occur from the former Goldstone mode, which one ceased to exist, and becomes activated.

Th-PB134

NONLINEAR OPTICAL PROPERTIES OF FERROMAGNETIC SEMICONDUCTOR WITH DYNAMIC GRATINGS PRODUCED BY COHERENT LIGHT BEAMS

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We consider a wide-gap donor type of ferromagnetic semiconductor (FMSC) in the spin wave temperature range in an external constant electric field. The front surface of FMSC is illuminated by a few coherent light beams (CLB) whose frequency satisfies the inequality $\hbar\omega << \varepsilon_g$ (ε_g is the energy-gap width). At these conditions CLB in FMSC may produce the static and dynamic grating of electron concentration, electron and magnon temperatures and nonequilibrum magnetization. The nonlinear optical phenomena in FMSC with dynamic gratings created by CLB are investigated. The high-frequency current and the nonlinear absorption coefficient are calculated. It is shown, that absorption coefficient consists of two terms. The first one is the coefficient of absorption by free electrons in the quantum frequency range for a linear response. The second term is the nonlinear response of the wave absorption coefficient modulated with coordinate. This proves that dynamic grating emerge in FMSC. It is shown, that with increasing of frequency, the nonlinear absorption coefficient grows, reaches a maximum at frequency $\omega \approx 4 \cdot 10^{12} s^{-1}$, and further smoothly decreases with increase frequency. Therefore the dynamic gratings considerably affects the processes of propagation and absorption of electromagnetic waves in FMSC

Th-PB135

SCATTERING OF ULTRACOLD NEUTRONS BY FERROMAGNETIC SEMICONDUCTOR WITH NON-EQUILIBRIUM MAGNON SUPERLATTICE

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We study the scattering of ultra colg neutrons by the surface of a ferromagnetic semiconductor (FMSC) with the non-equilibrium magnon superlattice that created by laser beams (LB). The reflection coefficient of the ultracold neutrons near the Bragg resonance (the neutron wave vector close to the superlattice period) has been calculated in the one-bang approximation. It is shown that the presence of the non-equilibrium magnon superlattice essentially changes the magnetic properties of FMSC. The reflection coefficient near the Bragg resonance considerably differs in comparison with this coefficient in a homogeneous FMSC even at small modulation of the non-equilibrium magnetization. The external constant electric field ($\vec{F}_0$) essentially affect the reflection coefficient. The ultracold neutron reflection coefficient sharply decreases with the field, reaches a minimum and then asymptotically approaches to the value typical for the homogeneous FMSC. Therefore varying a degree of the non-equilibrium magnetization and parameters of the magnon superlattice on can control the ultra cold neutron beams.

Friday, June 9, 2000

Fr-IA01

TRANSPORT, MAGNETIC AND TIME DEPENDENT EFFECTS IN METAL-INSULATOR DISCONTINUOUS MATERIALS

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Different series of multilayered $Co_{80}Fe_{20}(t)/Al_2O_3$(30 Å) films were prepared by ion-beam sputtering. We report on their structural characterization, static magnetization and on tunnel magnetoresistance (TMR) with the current-in-plane (CIP) and current-perpendicular-to-plane (CPP) geometries. It is found that $Co_{80}Fe_{20}$ layers are discontinuous within the Al_2O_3 matrix at thicknesses $t \leq 18$Å. In the CIP case, the thickness t can be optimized to give maximum TMR (~6.5 % for t = 10 Å) or maximum initial slope of TMR with field (~24 %/kOe for t = 13 Å) at room temperature. Magnetization data show that ferromagnetism onsets at $t \geq 13$ Å, indicating that the magnetic transition precedes electrical one in this system. The temperature dependence of TMR was found quite different for the two geometries: fairly strong for CIP and weak for CPP. To explain these features we propose a model taking into account the significant differences between short-range magnetic correlations within and across the layers. At $t < 14$ Å, a new phenomenon of slow electric relaxation was found, suggesting formation of highly non-equilibrium electronic states in the process of tunnel transport in such systems. An extension of the Sheng-Abeles approach to the case of finite concentrations of charged granules is proposed. Within a mean-field approximation, it gives a qualitative description of this phenomenon.

Fr-IA02

SPIN-DEPENDENT TRANSPORT IN MAGNETIC MULTILAYERS AND SANDWICHES WITH ACCOUNT FOR AN ELECTRONIC STRUCTURE AND INTERFACE ROUGHNESS

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General transmission amplitude (coefficient) for an electron Bloch wave with an arbitrary dispersion law coming in the ballistic regime from one metallic magnetic layer to another one through a spacer (metallic or insulator) is found for the case of perfect interfaces. The transmission amplitude with roughed interfaces has been obtained in the effective-mass approximation for the electron spectra (with different masses in different layers). The roughness is modeled by the short-range scatterers located at the interfaces.
The Boltzmann equation incorporating the obtained transmission coefficient has been solved and the difference of currents in the ferromagnetic (F) and antiferromagnetic (AF) configurations of an infinite multilayer has been found in the CIP geometry with accounting for spin-dependent scattering in a bulk of magnetic layers as well as for the specular and diffusive scattering at the interfaces. Contribution of a potential landscape for an electron and the quantum interference effect to the magnetoresistance of a multilayer was found.
The Landauer formalism and the obtained transmission coefficient were used for analytical and numerical studying the magnetoresistance ratio of magnetic sandwiches in the CPP geometry with a metallic and insulator spacer. It is shown that the giant magnetoresistance effect (GMR) in metallic sandwiches can be described in the effective-mass approximation for an electron spectrum with different effective masses in different layers.

Friday, June 9, 2000
Section A

Fr-OA01
ONE-DIMENSIONAL MAGNETOPHOTONIC CRYSTAL WITH A THIN RARE-EARTH IRON GARNET FILM

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One-dimensional photonic crystals with a thin rare-earth iron garnet film (magnetophotonic crystal: MPC) were formed by means of the combined method of RF sputtering and pulsed-light annealing. The media had multilayer structures of $(SiO_2/Ta_2O_5)^k$/ Bi:YIG/$(Ta_2O_5/SiO_2)^k$, where k is the stacking number of SiO_2/Ta_2O_5 multilayer film while Bi:YIG is the Bi-substituted yttrium iron garnet film with the composition of $Bi_{0.7}Y_{2.3}Fe_5O_{12}$. In good agreement with our theoretical prediction [1,2], the 1D-MPC exhibited considerably high transmissivity and large Faraday rotation at the designated localization wavelength of light, as shown in Fig.1, which results in a considerably high figure-of-merit parameter being very attractive for various MO devices including the optical isolator.

[1] M. Inoue et al., J. Appl. Phys., vol.85 (1999) 5768.
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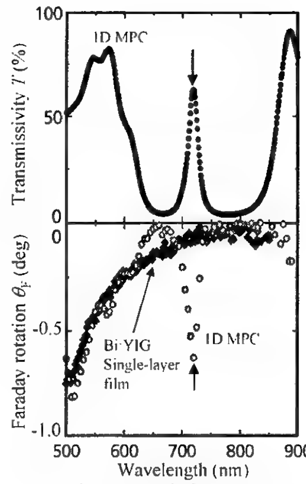

Fig.1 T and θ_F spectra.

Fr-OA02
SECOND HARMONIC LIGHT SCATTERING BY DISLOCATIONS IN MAGNETIC CRYSTALS

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It is well known that dislocations in magnetic crystals lead to changes in the magnetization distribution due to the magnetoelastic interaction and to the formation of so-called dislocation domains [1]. These domains can be observed by magnetization-induced optical second harmonic generation, which is a very effective tool for the investigation of magnetic domains [2,3].

In this presentation we theoretically investigate second harmonic light scattering by dislocations in magnetic crystals. For the description of the contribution of the elastic and magnetic subsystems to the nonlinear polarization we use nonlinear photoelastic and nonlinear magnetooptic tensors. The polarization characteristics of scattered radiation at the second harmonic frequency are studied.

This work is supported in part by INTAS, Grant No. 97-0705.

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Fr-OA03

ON THE HYSTERETIC MAGNETIZATION OF GRANULAR MAGNETIC SYSTEMS AT ROOM TEMPERATURE

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The magnetic hysteresis of granular bimetallic alloys of the family $Cu_{100-x}Co_x$ (x = 5 to 20) has been investigated at room temperature (i.e., well above the blocking temperature of Co nanoparticles). These alloys, prepared in ribbon form by planar flow casting, differ by total density of Co particles, average particle size, average interparticle distance, particle-size distribution. The magnetic hysteresis observed in this alloy family has been recently explained taking into account the effect of magnetic interactions of dipolar nature among magnetic-metal particles and introducing a "memory" term in the argument of the function which describes the magnetization behavior of an assembly of non-interacting, superparamagnetic particles [1]. The theory is applied to study in detail minor hysteresis loops, both symmetric and asymmetric, of all considered alloys. The remanence value of the examined minor loops, as well as the entire loop shape, are always well described by the model, except for very small vertex-field values (H_v < 400 Oe), where blocked-particle contributions are presumably no longer negligible. The model's success in coherently describing many different hysteretic phenomena in a wide range of vertex-field values leads one to conclude that the magnetic hysteresis of these granular $Cu_{100-x}Co_x$ alloys is dominated by dipolar interactions, at least at room temperature.

[1] P.Allia, M.Coisson, M.Knobel, P.Tiberto, F.Vinai, Phys. Rev. B60, 12207 (1999)

Fr-OA04

INDUCED UNIDIRECTIONAL MAGNETIC ANISOTROPY IN Fe_2Ti THIN FILMS

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The C14 Laves phase Fe_2Ti is stable in a wide compositional range. Within this range $Fe_{2+x}Ti_{1-x}$ orders ferromagnetically for x>0 and antiferromagnetically for $x \leq 0$[1]. Even slight changes in stoichiometry strongly alter the magnetic state which is pronounced for $x \approx 0$.
Thin films showing (110)- and (001)-texture, depending on stoichiometry, have been prepared using MBE deposition techniques. SQUID-magnetization measurements at various temperatures and magnetic fields have been performed. Temperature dependent measurements reveal ferromagnetism at elevated temperatures. Antiferromagnetic contributions are discernible below approximately 80 K. Consequently the temperature dependence of the magnetization deviates from Bloch-like behavior at low temperatures reminiscent of bulk samples [2].
Magnetic hysteresis loops taken after field-cooling are shifted significantly in opposite direction of the cooling field giving evidence for strong induced unidirectional anisotropy. Temperature increase causes the effect to gradually disappear above the antiferromagnetic ordering temperature. We suggest that exchange coupling effects at the interfaces of ferromagnetic and antiferromagnetic ordered regions cause this *Exchange Bias* effect, which is well known from other materials.

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Fr-IA03
MESOSCOPIC MAGNETS: DOTS, WIRES, AND PILLARS ON THE NANOMETER SCALE.

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Mesoscopic magnetic structures play an increasingly important role in magnetic storage technology, magnetic sensors, non-volatile random access memories, and „magneto-electronics“ in general. Lithography-type processes for making such structures, though having been quite successful, will not be covered in this talk. Rather, typical surface science approaches, involving adsorption, surface diffusion, epitaxial growth phenomena, and self-organisation will be exploited to produce and characterize mesoscopic magnetic structures. For example, magnetic wires may be made by step edge decoration on stepped single crystal surfaces by tuning surface diffusion. Likewise, magnetic dots may be created by exploiting localized adsorption on reconstructed surfaces. A particular challenging task is the magnetic characterization of such structures on the nanometer scale. The use of magnetic x-ray dichroism in photoemission microscopy for element-selective imaging of magnetic nanostructures is demonstrated. Recent progress in spin-polarized tunneling with a magnetic tip is presented, with a lateral resolution of a few nanometers at present.

Fr-OA05
DYNAMIC ANALISIS OF CURRENT INDUCED MAGNETIZATION SWITCHING IN SMALL DOMAINS

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Recently several experimental studies [1] confirmed the possibility of switching the magnetization direction in the small magnetic domains by pumping large spin-polarized currents through them. In the case of high exchange constant, magnetization of the domains is almost uniform and it is possible to describe the influence of current using simple equations proposed in [2]. In this work we analyze the stability and switching for different types of magnetic and shape anisotropy of a magnetic domain in a nanowire: a situation commonly realized in experiments.

[1] Tsoi, M. *et al.*, // PRL, **80,** p.4281 (1998); Myers, E.B *et al.*, // Science, **285**, p.867 (1999); Sun, J.Z. // J.Magn.Magn.Mat. **202**, p.157 (1999)
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Fr-OA06
ELECTRONIC AND MAGNETIC PROPERTIES OF THE OXYGEN ASSISTED GROWN Cr/Fe(001) INTERFACE

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We present a spin resolved Inverse Photoemission and Absorbed Current spectroscopies study on the early stages of the Cr/Fe(001) and Cr/Fe(001)-p(1x1)O interface formation. The peculiar magnetic properties of the Cr/Fe(001) system are hindered in thin films by the formation of island as well as by a strong atomic exchange mechanism which lead to the growth of a mixed Cr-Fe phase [1]. For Cr/Fe(001) films up to 3 ML thickness we find an antiferromagnetic coupling between the Cr atoms and the Fe substrate, while the typical oscillating behavior of the exchange coupling has its onset at 4 ML. On the other hand, it has been recently proved that surface oxygen, acting as a surfactant, induces a layer by layer growth of Fe on the Fe(001)-p(1x1)O surface [2]. Moreover the spin dependent properties of the Fe(001) surface are enhanced by oxygen absorption [3]. Thus we have followed the evolution of the electronic and magnetic properties of Cr films grown on the Fe(001)-p(1x1)O surface, aiming to obtain a more ordered interface. The spin resolved electronic structure and the role of oxygen on the resulting system are discussed evidencing the influence of two different substrate on the Cr film magnetic properties.

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Fr-OA07
COMPETING MAGNETIC ANISOTROPIES IN Ho/Tm SUPERLATTICES

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We report about magnetoelastic (MEL) stress and magnetization measurements, between 10K-120K and magnetic field, **B** (up to 12 T), applied along the hcp structure **b** and **c** directions for Ho_8/Tm_{16} and Ho_{30}/Tm_{16} magnetic superlattices (SL). The low field (**B** = 0.005 T) magnetization clearly shows the coexistence of Ho and Tm magnetic order below $T^* = 60$ K, although the Ho blocks are magnetically ordered below $T_N = 100$ K for both SL's. The high field magnetization is strongly reduced below ~60K when **B** is applied along the basal plane (b.p.) **b**-axis when is compared with that one along the **c**-axis (~ -75% for Ho_{30}/Tm_{16} SL). This shows that saturation magnetization along **b** is not achieved even below 30K. By the other hand, below T^*, the comparison of the high field magnetization for our SL's with the Ho/Lu ones [1] also shows a magnetization reduction (~ -75%) along **b**. This is a clear indication of a Ho block polarization by the Tm blocks. It means a competition between the Ho and Tm anisotropies.

From our symmetric MEL stress, σ(**b**,**b**) and σ(**b**,**a**), measurements we could perform a detailed analysis of the thermal variation of the orthorhombic MEL stress mode $\mathbf{B}^{\gamma,2} = 2[\sigma(\mathbf{b},\mathbf{b})-\sigma(\mathbf{b},\mathbf{a})]$ for the Ho/Tm SL's. $\mathbf{B}^{\gamma,2}$ shows an abrupt decrease below about $T^* = 60$ K at 12 T, which reveals the Tm block **c**-axis ordering. Also, $\mathbf{B}^{\gamma,2}$ shows a sign change below 45 K, which can be interpreted as the competition between the Ho (**b** easy) and Tm (**c** easy) anisotropies.

[1] J. I. Arnaudas, A. del Moral, M. Ciria, G. J. Tomka, C. de la Fuente, P. A. J. de Groot, R. C. C. Ward and M. R.Wells.//J. Magn. Magn. Mater., 156, (1996), p.421-422.

Fr-OA08

COMPETING COMMENSURATE AND INCOMMENSURATE MAGNETIC STRUCTURES IN DHCP Ce/Nd SUPERLATTICES

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The chemical and magnetic structures of cerium/neodymium superlattices grown by molecular-beam epitaxy have been determined using x-ray and neutron-diffraction techniques. Nd is a dhcp light rare-earth metal and exhibits a variety of multi-q magnetic structures. Ce is also a light rare-earth metal, but it displays a succession of different chemical structures as temperature and pressure are varied. The dhcp phase, β-Ce, orders antiferromagnetically. The x-ray studies show that the Ce in the Ce/Nd superlattices adopts a dhcp structure of high crystalline quality, and that the stacking sequence is coherent over many bilayer repeats. The details of the magnetic structures of Ce/Nd were found to differ from those of the bulk materials and other Nd superlattices. In the $[Ce_{10}/Nd_{30}]_{70}$ sample incommensurate order was found at the wave-vector associated with ordering on the hexagonal sites in Nd. This magnetic scattering had maximum intensity at ~7K and then decreased. A ferromagnetic moment was also detected. The drop in incommensurate magnetic scattering seems to be correlated with the commensurate moment saturating, indicating that the two magnetic structures could be in competition. Superlattice samples with higher Ce content show an increase in the commensurate structure at the expense of the incommensurate order. The relationship of these results to the behaviour of light rare-earth metals and alloys at high pressures will be discussed.

Fr-IA04

DEVELOPMENT OF MAGNETIC NANOSTRUCTURES FOR APPLICATION AS LINEAR MAGNETORESISTIVE SENSORS

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Since several years, we are developing a research in the domain of magnetic nanostructures, based on the use on the use on self-organised non planar substrates. For that purpose, we are exploiting the remarkable step bunching properties of vicinal Si(111) surfaces. We have developed several types of magnetic nanostructures on top of such surfaces: thin films, spin valve structures as well as, more recently, magnetic tunnel junctions.
In a first part we will describe in details the specific magnetic and transport properties which can be induced by the topological modulation: magnetic anisotropy, specific magnetisation reversal mechanism, giant magnetoresistance (GMR)[1] as well as tunnel magnetoresistance (TMR)[2].
In a second part, we will show how these nanostructures can be advantageously used in magnetoresistive sensors. A first generation of sensor has been developed, which is based on the transverse measurement of the anisotropic magnetoresistance (planar Hall effect)[3]. More recently, we have studied several concepts of linearisation of the GMR or TMR signals.

[1] A. Encinas et al., Appl. Phys. Lett., 71, 3299 (1997)
[2] F. Montaigne et al. Appl. Phys. Lett., submitted
[3] F. Montaigne et al., Sensors & Actuators, to appear.

Fr-IA05

FMR PECULIARITIES IN ULTRATHIN AND GRANULAR FILMS

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Very small amounts of magnetic material that are peculiar for ultrathin (up to 50Å) and granulated (with content of magnetic phase less than 20 at.%) films, embarrass to use the most traditional methods of investigation. Among methods that can be used is also FMR (SQUID, MOKE, MR and EHE). However in these cases it is important to account the principal (significant effect of substrate roughness and film surfaces on shape- anisotropy, effect of magnetic clusters (granules) interactions and account of their form, etc.) and methodical (separation of FMR signal coming from magnetic phase and background of EPR signal coming from substrate, cap, sample holder, etc.) factors as well. Some factors should be accounted also in studying more complex systems, such as bi- and trilayered ultrathin films with metal or nonmetal spacers. All this peculiarities will be discussed.

Fr-OA09

INHOMOGENEOUS FMR MODES IN $[Fe/Cr]_n$ SUPERLATTICES WITH A STRONG BIQUADRATIC COUPLING

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We studied magnetization curves and ferromagnetic resonance spectra in a set of epitaxially grown $[Fe/Cr]_n$ superlattices with a relatively large value of biquadratic coupling constant. The experiments were performed at room temperature with steady magnetic field lying in the sample plane. Both the transverse and the longitudinal FMR excitation was used in the 9.5-37 GHz frequency range. A number of absorption lines was observed in the FMR spectra, including the acoustic, optical and several additional resonance modes [1]. The resonance spectra and magnetization curves were calculated using the biquadratic coupling model. The analytical consideration was suggested for an infinite superlattice and numerical — for a finite number of magnetic layers in the sample. All the experimentally observed FMR modes found their explanation in the frame of the performed calculations. We demonstrated, that the static and the resonance experimental data could be simultaneously described using the same values of bilinear and biquadratic coupling constants with a fair precision. Similar investigations are planned to be performed at low temperatures.

[1] A. B. Drovosekov, O. V. Zhotikova, N. M. Kreines, D. I. Kholin, V. F. Meshcheryakov, M. A. Milyaev, L. N. Romashev, and V. V. Ustinov, Zh. Eksp. Teor. Fiz. **116**, 1817 (1999)

Fr-OA10
SPIN-WAVE SPECTRUM OF MULTILAYERS WITH FINITE THICKNESSES OF INTERFACES

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To describe a multilayer structure with arbitrary thicknesses of the interfaces between layers we introduce a model in which the dependence of a material parameter along the axis of such a superlattice is described by a Jacobian elliptic sine function. Depending on the value of the modulus $\boldsymbol{k}$ of the elliptic function, the model describes the limiting cases of multilayers with sharp interfaces ($\boldsymbol{k} = 1$, $d/l = 0$, where d is the thickness of the interface, l is the period of the superlattice), and of sinusoidal superlattices ($\boldsymbol{k} = 0$, $d/l = 1/4$), as well as all intermediate situations. We investigate the wave spectrum in such a superlattice.
The dependences of the widths of the gaps in the spectrum at the boundaries of all odd Brillouin zones on the ratio d/l are found. It is shown that the thicknesses of the interfaces can be determined if the experimental value of the relation between the widths of the first gap $\Delta\nu_1$ and any other gap $\Delta\nu_n$ is known.
The work was supported by the NATO Science Program and Cooperation Partner Linkage Grant No 974573, and Network Infrastructure Grant No 973201.

Fr-OA11
MAGNETIC STRUCTURE OF $NiFe_2O_4$ NANOPARTICLES IN FERROFLUIDS

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New ionic ferrofluids containing $NiFe_2O_4$ nanoparticles of the size well below 10 nm are investigated. The grain crystalline structure is probed by TEM and X-ray scattering. Static magnetization and field-induced birefringence measurements are performed on three fluid samples differing by particle volume fraction. We find that, to the contrary to ferrofluids containing γ-Fe_2O_3 nanoparticles [1], in the nickel ferrite one magnetization does not saturate even in a field ~5 Tesla. Meanwhile, birefringence readily does. Cross-examining of the results of those two types of macroscopic tests turns down completely a simple single-domain particle model. Instead, it completely agrees with the nut–shell scheme of a particle as consisting of a core with a uniform magnetization and a surface layer stowed with a spin-glass like arrangement.
Partially supported by CNPq, CAPES, FAP-DF (Brazil) and RFBR grant 98-02-16453.

[1] Hasmonay E., Dubois E., Bacri J.-C., Perzynski R., Raikher Yu.L., Stepanov V.I.// Europ. Phys. Journ. B 5 (1998) 859.

Fr-OA12

FORMATION OF INTERMETALLIC Al_xFe_{1-x} FROM MECHANICAL ALLOYING OF Al/Fe_2O_3 COMPOSITE

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Mechanical alloying is widely used for production of nanosized composites with promising applications in fields like catalysis and high-frequency devices. In this work, we present a structural and magnetic study on the Al_xFe_{1-x} intermetallic obtained from reduction of Al/Fe_2O_3 composites by mechanoshyntesis. X-ray, Mössbauer and magnetization measurements were combined to investigate the resulting phases and their microstructure after several hundred hours of milling, and compared with crystalline AlFe (B2) phase.

The resulting AlFe phase shows magnetic order at room temperature, due to short-ranged ionic disorder induced by milling. Values of $\langle e \rangle = 0.5$-0.7% for the root mean square strain were found from x-ray data. Mössbauer spectra showed a distribution of hyperfine fields with an average value of $\langle H_{hyp} \rangle = 290(2)$ kG at room temperature, which increases to $\langle H_{hyp} \rangle = 310(2)$ kG at 4.2 K. Magnetization data indicate strong irreversibility up to $T = 400$ K, without signs of spin-glass state down to 2 K. This behavior is still present in samples heated at 710 C in vacuum, suggesting persistence of short-range disorder. The magnetic properties of these samples are explained from the development of antiphase boundaries (APB) leading to ferromagnetic clusters.

Fr-IB01
MAGNETIC RELAXATIONS AND MAGNETIZATION PROPERTIES OF FERROMAGNETIC ALLOYS

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The magnetic (structural) relaxation (MR) can be understood as the short range reordering of uniaxial point defects and their clusters compliant with the principal of the minimum free energy of the ferromagnetic systems. The MR is often used at the magnetic properties optimization. It brings a lot of magnetization phenomena as a consequence of the time-temperature dependent domain wall potential deepening. The domain wall movement is described by the Néel's equation. The occurence of the Perminvar effect (PE) in some crystalline, amorphous and nanocrystalline ferromagnetic alloys gives an experimental evidence of the parabolic form of the DW potential. Its curvature is strongly influenced by the DW stabilization caused by the MR. The critical fields of the PE, at which DWs begin to move irreversibly, were investigated in the AC magnetic fields from the range 10^{-4} - 10^{2} A/m. It was concluded that the MR makes the pinning field distributions narrower and shifts them to higher values.
The MR significantly enlarge the imaginary part of the complex susceptibility caused by the additional viscous damping of the DW movement. The loss factor tg δ (T) is proposed for monitoring the segregation kinetics of N from the Fe-N solid solutions.
The most convenient method for the study of the MR kinetics and the distributions of its activation parameters is the magnetic aftereffect of reluctivity (MAE). It was show that the additions of Cr enlarge the entropy of the amorphous Fe-B systems and make them more stable.

Fr-IB02
PREPARATION, STRUCTURE, AND MAGNETIC AND MAGNETOOPTICAL PROPERTIES OF $Bi_3Fe_5O_{12}$

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So called hypothetical garnet $Bi_3Fe_5O_{12}$ (BIG) has attracted much attention from points of magnetooptical material research and application. It was found to be able to crystallize onto a substrate with garnet structure using vapor phase epitaxy technique[1]. As the preparation techniques, so far ion-beam-, rf-, and ECR-sputtering have been successfully applied and recently laser ablation deposition is extensively developing.
The features of structure will be discussed based on X-ray diffraction and Raman scattering data. The magnetic properties such as magnetization, Curie temperature, anisotropy, and
effects of substitution of nonmagnetic ions for Fe ion will be discussed based on measurements using vibrating sample magnetometer and conversion-electron-Mossbauer spectrometer. The Faraday rotation angle of measured at 633 nm at room temperature is more than -8 deg/m which is much larger than the extrapolated value of 6 deg/m obtained from $Y_{3-X}Bi_XFe_5O_{12}$ system. The magnetooptical Kerr rotation angle was -1.2 deg at 490 nm at room temperature.

[1] T. Okuda, T. Katayama, H. Kobayashi, and N. Koshizuka: J. Appl. Phys. 67, 4944 (1990).

Friday, June 9, 2000
Section B

Fr-OB01
ORBITAL MAGNETIC MOMENT INSTABILITY AT THE SPIN REORIENTATION TRANSITION OF $Nd_2Fe_{14}B$

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$Nd_2Fe_{14}B$, the highest performance permanent magnet material, exhibits a Spin-Reorientation Transition (SRT) at around 135 K. We have performed highly accurate soft X-ray Magnetic Circular Dichroism, XMCD, at the Fe $L_{2,3}$ and Nd $M_{4,5}$ edges to monitor the behavior of the Fe and Nd sub-lattice magnetizations through the SRT. These experimental results evidence a strong non-collinearity between Fe and Nd moments in the low temperature phase.
Application of the XMCD sum rules to the Fe $L_{2,3}$ edges yields the behavior of $\langle L_z \rangle$ and $\langle S_z \rangle$ as a function of temperature. We demonstrate that the average Fe orbital moment a) is proportional to the macroscopic Fe anisotropy constant, and b) diverges at 15 K below the reorientation transition temperature which is indicative of critical behavior and related to a tetragonal distortion. These results give experimental confirmation of the mutual dependence between orbital moment, macroscopic anisotropy and tetragonal distortions that has recently been suggested [1]. It is argued that the critical behavior of the orbital moment is at the origin of similar divergences observed in Mössbauer [2] and Hall-effect [3] data.

[1] O. Hjortstam et al., Phys. Rev. B. **55**, 15026 (1997)
[2] H. Onoedera et al., J. Magn. Magn. Mater. **68**, 6 (1987); **68**, 15 (1987).
[3] J. Stankiewicz and J. Bartolomé, Phys. Rev. Lett. **83**, 2026 (1999).

Fr-OB02
MAGNETIC VISCOSITY STUDY OF THIN FLEXIBLE RE MAGNET-FOILS

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A magnetic viscosity study of flexible thin foils containing rare-earth alloy-powders, $Sm_2(Co,Cu,Fe,Zr)_{17}$, and $Nd_{12}Fe_{82}B_6$ has been performed in order to characterize the time-dependent effects of these new and technologically relevant materials.
Magnetic viscosity and irreversible susceptibility have been measured as a function of the magnetic field (0-5 T) and temperature (5-300 K) using a SQUID magnetometer. From these data, we have determined the temperature and field dependence of the fluctuation field, S_v, and the activation volume, V_{act}. Characteristically different behaviour of these magnitudes is observed among both magnets. We explain these results in terms of the different coercivity mechanism involved in each process. From hysteresis loop measurements we demonstrate that for SmCo compound pinning mechanism dominates while for NdFeB one the nucleation is the dominant mechanism.
Moreover, hysteresis loops measurements performed for NdFeB at different temperatures through the spin reorientation transition (SRT) which this compound exhibits at 135 K, evidence a reduction of the permanent magnet performances which this compound suffers below the SRT. Exotic hysteresis loops are observed at low temperatures which are explained in terms of the new magnetic domains detected below SRT [1].
[1] Pastushenkov Y.G., Forkl A. and Kronmuller H., J. Magn. Magn. Mat. 174 (1997) 278

Fr-OB03

PRODUCTION OF $Pr_{16}Fe_{76}B_8$ MAGNETS BY BLENDING WITH COBALT

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The paper describes the production of sintered Pr-Fe-B magnets by a powder blending process. High energy magnets are produced by blending with Co. Magnets are produced by varying the Co content from 0 to 10 %. Both the effectiveness of blending as a process and the variation of properties by varying Co content are investigated. Effect of heat-treatment on magnetic properties and microstructure is also investigated. There is an improvement in the Curie temperature and elctrochemical corrosion resistance of the blended magnets.

Fr-OB04

THE MAGNETIC DOMAIN STRUCTURE ON THE BASAL PLANE OF $Fe_{14}Nd_2B$ SINGLE CRYSTALS DURING THE SPIN-REORIENTATION TRANSITION

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The magnetic domain structure of $Fe_{14}Nd_2B$ single crystals has been studied on the (001) planes from room temperature down to 4,2 K by means of the magneto-optical Kerr effect. The external magnetic fields up to O,5 T were applied parallely or perpendicularly to the specimen surfaces. On the basis of the analysis of the domain structure changes a model for the magnetization distribution in the volume of $Fe_{14}Nd_2B$ single crystals for the anisotropy type "easy cone" (temperature region 135 K >4,2 K) has been developed. The general expressions for the domain wall energy density γ have been performed for the new types of boundaries in tetragonal magnetics with "easy cone" anisotropy. For the construction of the model of magnetization distribution in complicated domain structures typical for the tetragonal crystals with the anisotropy type "easy cone", the calculations of the domain wall energy density for the possible types of the domain walls in low temperature region have been done.
The obtained results prove the importance of our investigations consering the problem of temperature stability for the permanent magnets on the basis of $Fe_{14}Nd_2B$.

[1] Pastushenkov Yu.G., Forkl A., Kronmüller H. // Journ. Magn. Magn. Mater., 174, (1997), p.278.
[2] Pastushenkov Yu.G., Suponev N.P., Dragon T., Kronmüller H. // Journ. Magn. Magn. Mater., 196, (1999), p.856.

Fr-IB03

DYNAMIC DOMAIN STRUCTURE AND CORE LOSSES BEHAVIOUR IN TEXTURED SOFT MAGNETIC MATERIALS

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Soft magnetic alloys a iron form a base thin-ribbons materials for cores, widely used in alternating magnetic fields. Processes their remagnetization and electromagnetic properties level in the significant degree are defined by the construction and behaviour of magnetic domain structures.
Consider particularies of realignment 180^0 main and supplementary domains under dynamic remagnetization – a growing of number domains, bowing planes and unidirectional offset of domain walls, dependent from orientation to axis of magnetic texture, springy deformation, sizes an crystals, degrees to stabilization of magnetic structure, amplitudes to magnetic inductions and frequencies remagnetization. On the example transformer Fe-Si steels and amorphous ferromagnetic alloys a iron are discuss methods of parameter governing domain structure for reducing the magnetic losses, connected with making the tensile stress by magnetical active covering, periodic sharing the magnetic fields of dispersing by magnetic-structural barriers under secondary recrystallizations and ion-beam processing, destabilization of domain structure by thermomagnetic processing in magnetic fields of increased frequency, developped in IMP with the participation of employees IEP, ICSS and SRIEPA.
The study was supported by RFFR (Project 99-02-16279).

Fr-OB05

SIMULATION OF SPIN SYSTEM FOR NONDESTRUCTIVE EVALUATIONS OF IRON-BASED MATERIALS

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Magnetic properties were simulated by Monte Carlo method taking in three dimensional Heisenberg model for nondestructive evaluations of iron based materials. These simulations include atomic voids or edge dislocations caused by e.g. applied tensile stresses, where localized spins supposed distributed over the cells of 50^3=125000. The exchange and magneto-elastic interactions were assumed effective among the first and second nearest neighbors. These simulations realize magnetic hysteresis curves depending on the various tensile stresses and the local residual stresses, which are important factor for the nondestructive evaluation of material using magnetic sensors and X-ray diffraction. we are comparing these simulations with the experimental results of magnetic leakage flux and Barkhausen effects [1].

[1] Koji Yamada et al. J. Magn. Soc. Japan, Vol.23, pp.718-720 (1999).

Fr-OB06
MAGNETIC PROPERTIES OF MULTI-PHASE AMORPHOUS AND NANOCRUSTALINE MATERIALS

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By now, it is well known that non-reversible changes in short- and middle-range atomic order occur during heating, cooling and alloying of melts. However, the evolution of structure and magnetic properties of amorphous alloys was not investigated in detail. Here we represent the results of an extensive study in this field concerning the specific amorphous alloy with improved magnetic properties. The main peculiarity of this alloy is the multi-phase structure containing ferromagnetic and antiferromagnetic zones with different values of magnetic anistropy and magnetostriction. We believe that the structure of amorphous materials may reflect the structure of melt which has been inherited from the crystalline structure of the alloy and was preserved during the melt solidification.
The structures of Fe-base amorphous and nanocrystalline alloy ribbons were characterized by electron microscopy and micro-analyses (SEM, HR SEM,TEM, EDS SEM, EDS TEM, WEDS SEM). This allowed us to evaluate the composition, the structure and the crystallographic orientation of phases present in the matrix. In addition, the nanocrystalline cluster model of the amorphous state was used with the aim to characterize the influence of structure on the magnetic properties of multi-phase amorphous alloys.
This presentation includes the results of: 1.Development of new multiphase amorphous soft magnetic alloys, and their applications .2.Preparation of amorphous materials using special melt treatment methods. 3.Structure peculiarities of multi-phase amorphous alloys.

Fr-OB07
RELAXATION AND EARLY STAGE OF CRYSTALLIZATION IN NANOCRYSTALLINE PRECURSORS

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The common aspects of irreversible structural relaxation and nucleation will be treated in nanocrystalline precursor glasses based on the concept of the defect structure of glassy alloys introduced by Egami [1]. The applicability of the outlined concept is experimentally supported by measurements of thermal expansion carried out below and above the nucleation temperatures in the appropriate glassy state.
The degree of structural relaxation, the nucleation process as well as the early stage of nanocrystallization will be followed also by measurements of saturation magnetization and by the determination of the amorphous Curie temperature change during the process outlined [2].
The attainable magnetic softness characterized by the coercive force, initial and maximal permeability will be compared in structurally relaxed, partially and fully nanocrystallized state.
Finally some results on power loss (loss as a function of induction at different frequencies) and the appropriate domain structure will be compared after the applied heat treatments.

[1] D. Srolovitz, T. Egami and V. Vitek, Phys. Rev. B 24 (1981) 6936
[2] A. Lovas, L.F. Kiss and I. Balogh, presented in SMM14 (Balatonfüred, Hungary), to be published in J. Magn. Magn. Mater. (2000)

Fr-OB08

A STUDY OF ANTIFERROMAGNETIC AND SINGLE STATES IN THE QUASI-ONE DIMENSIONAL HEISENBERG MODEL WITH RANDOM EXCHANGE BONDS WITH S=1/2 BY QUANTUM MONTE CARLO METHOD

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Antiferromagnets (AFM) with strong intra- (J_1) and weak inter- (J_2) exchanges normal distributed between nearest neighbors are studied in terms of Heisenberg quantum model with spin S=1/2 and alternating antiferromagnetic bond ($J_1/I=1\pm\delta$) using mean- field approximation and quantum Monte Carlo method. The thermodynamic quantities, two- and four spin correlation functions for longitudinal and transverse spin components, their correlation radius are calculated. The phase boundary between long range ordered AFM and random singlet state is determined at the plane of exchange normal variance (D) and normalized intraexchange ($\lambda=J_2/J_1$) and is equal to $D_c=1.2(2)z\ \lambda$ (z- the number of nearest chains). The approximation functions of staggered magnetization is $\sigma(D)\approx0.80(4)\ (D_c\text{-}D)^{0.41(3)}$, energy is $(E(D)\text{-}E(0))\approx\text{-}\lambda/exp(1.5\ z\lambda/D)$, correlation radius is $\xi(D) \approx 85(4)\ \lambda\ ln\ (1/(D_c\text{-}D))$ are estimated at low temperatures for $\lambda<0.25$. The range of mass singlet state for $D<D_c=0.45(7)\ \delta^{0.7(1)}$ is founded in terms of Heisenberg model with random alternating bonds. A variance of exchange for amorphous spin-Peierls $CuGeO_3$ compound is estimated and is equal to $\sqrt{D}$ =72 K.

Fr-IB04

MAGNETOSTRICTION IN FERROMAGNETIC SHAPE MEMORY ALLOYS

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There is intense interest in the development of new magnetostrictive materials having large strains. Recent experiments [1,2] showed that the ferromagnetic shape memory alloys (SMA) have some perspectives to generate the significant magnetic field induced deformations. Taking into account the high mobility of the martensite transformation twins, the corresponding magnetic measurements were performed with using the SMA Ni-Mn-Ga and Fe-Pd. It is concluded that the condensation of the soft acoustic phonon mode TA2(q=1/3<110>) takes place at $T = T_i>M_s$ in Ni-Mn-Ga alloy (M_s-martensite start temperature). Magnetic property anomalies accompany this phase transition which can be interpreted as a transition to an intermediate phase. The characteristic temperatures M_s and T_i are close in some alloys. The simultaneous action of the lattice instabilities connected with the formation of martensite and intermediate phases produces the essential decreasing of the elastic constants and as a result the strong growth of the high temperature phase magnetostriction nearly at $T=M_s$. The behaviour of the martensitic phases in magnetic field also discussed.

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Th-IB05

LARGE MAGNETIC-FIELD-INDUCED STRAINS IN Ni-Mn-Ga ALLOYS DUE TO REDISTRIBUTION OF MARTENSITE VARIANTS

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Magnetic field control of shape of ferromagnetic alloys with martensitic structure recently was suggested and advantages of using those kinds of materials as actuators was substantiated. The suggestion was based on the fact that crystallographic anisotropy of martensitic crystals encourages the presence of strong magnetic anisotropy. The increasing of fraction of martensite variants favorably oriented in magnetic field due to movement of twines boundary would appear to be more advantageous process in comparing with process of magnetization rotation for materials with strong easy axis magnetic anisotropy.
The polycrystalline and single crystal samples of near-stoichiometric Ni_2MnGa alloys have been investigated. It was confirmed that short <001> c-axis in tetragonal martensite structure of the alloys is the easy axis of magnetization. In the martensitic phase the reversible reorientation of martensitic c-axis between two directions after 5% compression is shown. The same reversible reorientation of martensitic variants under magnetic field occurs in the martensite single crystal samples without any preliminary treatment. The martensite structure reorientation occurs only between two sample directions, the third one remains the axis of hard magnetization. The field-induced reorientation of martensitic variants is accompanied with more than 4% sample dimension changes. The same value of field-induced shape changes has been obtained for polycrystalline samples after appropriate thermo-mechanical treatment, that is the largest one for polycrystalline near-stoichiometric Ni_2MnGa alloys.

Fr-OB09

PREPARATION OF RIBBONS OF IRON ALLOYS WITH HIGH Si CONTENT BY MELT SPINNING AND ANNEALING IN HYDROGEN FLOW

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Recently [1] we demonstrated using spectrometric methods, scanning electron microscopy and electron probe microanalyses that it is possible to extract boron from amorphous ribbons by annealing in hydrogen flow. This method is applied to FeCoSiTMB ribbons (TM = Mn, Cr, Ni, Cu), leading to boron-free crystalline FeCoSiTM ribbons for compositions which are not accessible by traditional metallurgy (casting, forging, rolling) because of their brittleness. The coercivity of properly annealed ribbons ranges between 0.5 and 1 A/cm. These values compare well to conventionally prepared FeCo alloys. The magnetisation in a field of 15 kA/cm varies from more than 2 T to about 1.7 T for FeCo alloys with addition of different weigth percent Si and TM.

[1] G. David, S. Roth, J. Eckert, and L. Schultz, J. Magn. Magn. Mater. (submitted).

Friday, June 9, 2000
Section B

Fr-OB10
FABRICATION Ni-Zn-Cu FERRITE POWDERS AND POLYMER PASTES

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Ni-Zn ferrites have been used as the core in inductors and transformers for many years. These materials show unique magnetic and electrical properties at high frequencies. Traditional ferrites have been fabricated by ceramic methods. Recently, chemical methods have been investigated as they give better compositional control, chemical homogeneity and finer particle size than the ceramic method. The trend in the microelectronic industry has moved towards the planarisation of devices has generated a large interest into the development of magnetic materials which have excellent soft magnetic properties at high frequencies. It would be advantageous if the materials could be directly screen-printed on to a circuit board for economical reproducibility of devices. Research has been carried out previously on the use of metallic glass powders as the functional part of a polymer thick film pastes [1]. However, ferrites are known to have higher electrical resistivity than metallic glass powders. This paper will report on the physical, magnetic and electrical properties of $Ni_{0.8-x}Zn_{0.2}Cu_xFe_2O_4$ (x = 0, 0.2, 0.4, 0.6, 0.8) powder and polymer based thick film pastes prepared from metal nitrates by precipitation in sodium hydroxide [2].

[1] L. K. Powell, I. Z. Rahman, and M. A. Rahman. Cian O'Mathuna and Stephen O'Reilly, Proceedings of AMPT'99, (1999), p417.
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Fr-OB11
GIANT MAGNETOACOUSTIC EFFECT CAUSED BY NUCLEAR MAGNETISM

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Acoustic transparency of monocrystal $KMnF_3$ was investigated. The magnetic field **H** and frequency **f** dependence of off passed acoustic pulse amplitude **U** were measured. A narrow (near 100 Oe of a magnitude and 10^0 of a direction) and a deep ($\mathbf{U}_{min}/\mathbf{U}_{around} \sim 0.1$) minima of **U**(H) curves were observed. The effect exist into NMR frequency interval only.
The magnitude of the effect don't yield to electron magnetoelastic effects, but it is caused by nuclear magnetism, which at 10^5 time smaller then electron one. Because it was named by giant magnetoacoustic (GMA) effect.
The interference mechanism for description of GMA effect was proposed.

Fr-OB12

EFFECT OF HYDROGEN ON THE MAGNETOCRYSTALLINE ANISOTROPY AND MAGNETIC PHASE TRANSITIONS OF $RFe_{11}Ti$ SINGLE CRYSTALS

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The effects of hydrogen in $RFe_{11}Ti$ compounds have been studied by various groups, however, of the most amount of measurements have been carried out on powder samples. This complicates the interpretation of changes in magnetic properties of the H modified $RFe_{11}Ti$ compounds, especially in magnetocrystalline anisotropy (MCA). The purpose of this work is to study MCA (MCA) and spin-reorientation transitions (SRT) in single crystal hydrides $RFe_{11}TiH_x$ (x=0,1). A systematic investigation of the intrinsic magnetic properties of $RFe_{11}TiH_x$ (x=0,1) single crystal has been performed by means of torque and vibrating specimen magnetometery techniques and high-field magnetization measurements.
The obtained results indicate that drastic changes in the magnetic anisotropy are observed after the interstitial hydrogen insertion. A magnetic phase diagram of $RFe_{11}TiH$ has been proposed. For $HoFe_{11}Ti$ the **c** - axis is the easy magnetization direction (EMD) in whole temperatures range, while $HoFe_{11}TiH_1$ exhibits a axis-to-cone transition at about 140K. From phase diagram one can see that the hydrogen represses uniaxial states in $TbFe_{11}TiH_1$ and $DyFe_{11}TiH_1$.
This effects can be explained by strong increase in rare-earth sublattice contribution to total magnetic anisotropy and increase parameter A_{20}. Our calculations of the change of A_{20} under hydrogenation give values of -25-50 Ka_0^{-2} per hydrogen atom.
The work has been supported by RFBR Grant N99-02-17821 and N96-15-96429.

Fr-PB001
MAGNETIC BEHAVIOR OF $xB_2O_3(1-x)[V_2O_5 \cdot PbO]$ GLASSES

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Magnetic susceptibility measurements were carried out between 77 K and room temperature on $xB_2O_3(1-x)[V_2O_5 \cdot PbO]$ glasses ($0.05 \leq x \leq 0.9$). The temperature dependence of the reciprocal magnetic susceptibility is linear in the entire composition range, obeys the Curie law and denotes a paramagnetic behaviour of the samples. This indicates that the magnetic V^{4+} ions from the glass samples do not participate to superexchange interactions. It is to be noted that in the V_2O_5-PbO glass matrices for V_2O_5 contents higher than 50 mol% the temperature dependence of the reciprocal susceptibility obeys a Curie-Weiss law and denotes that the V^{4+} ions are involved in superexchange magnetic interactions. This type of behaviour is not evidenced for the investigated $xB_2O_3(1-x)[V_2O_5 \cdot PbO]$ glasses, despite the fact that the molar fraction of the V^{4+} ions is approximately the same in both cases for the samples containing 50 mol % V_2O_5. The results suggest that the presence of B_2O_3 in the samples determines such a distribution of V^{4+} ions in the vitreous network that hinders the superexchange interactions.
The composition dependence of the Curie constants and of the molar fraction of V^{4+} ions indicate a higher molar concentration of V^{4+} ions with the increase of B_2O_3 content in the samples. At the same time the composition dependences reflect that an increasing number of V^{5+} ions are going into the ionic state V^{4+}.

Fr-PB002
THE HALL EFFECT AND ATOMIC STRUCTURE OF TRANSITION METAL AMORPHOUS ALLOYS

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The temperature dependence (4.2-300 K) of the Hall coefficient $R_H(T)$ in Re-T (T = Cr, Nb) amorphous alloys have been measured. The anomaly (deep minimum) of $R_H(T)$ dependence in Re-Cr alloys has been observed with the absence of it in the case of Re-Nb. The temperature of this anomaly is increased with increasing the concentration of Cr atoms. It is indicative of existence of the phase transition in Re-Cr amorphous alloys. To reveal the nature of this effect the complex of low-temperature measurements of galvano-magnetic properties has been done: magnetoresistance $\rho(H)$, electrical resistivity $\rho(T)$, ac susceptibility $\chi(T)$ and dc magnetization $M(T)$.
Correlation of dependencies of transition temperature T_0 on the composition with the change of cluster distribution by sizes and the change of parameters of clusters with changing the composition of alloys is observed [1].

[1] Barmin Yu.V., Bataronov I.L., Bondarev A.V. X-ray Diffraction Study and Computer Simulation of Atomic Structure of Rare-earth and Transition Metal Amorphous Alloys // this conference.

Fr-PB003

X-RAY DIFFRACTION STUDY AND COMPUTER SIMULATION OF ATOMIC STRUCTURE OF RARE-EARTH AND TRANSITION METAL AMORPHOUS ALLOYS

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The atomic structure of Re-Tb and Re-Cr amorphous alloys was studied by DRON-3 θ-θ-diffractometer in geometry of reflection using MoK_α radiation and graphite monochromator in the diffracted beam. The experimental curves I(θ) were corrected for air background, polarization and absorption and normalized into electron units by the Krogh-Moe — Normann method. Then, having regard for anomalous dispersion of the atomic scattering factor f(k), we calculated the structural factors S(k). The radial distribution functions (RDF) were calculated by smoothing the structural factor with Hermite and Laguerre functions.

The computer simulation of atomic structure of Re-Tb and Re-Cr amorphous alloys was carried out by static relaxation (gradient) method and by molecular dynamics method. For the description of interatomic interaction in these systems we constructed a model polynomial potential. Good agreement between model and experimental RDF was obtained. The values of short-range order parameters (coordination spheres radii, coordination number of the first sphere) are also consistent to the experiment.

Atomic clusters were determined as groups of atoms of one species which are in immediate contact with each other. For models of Re-Tb and Re-Cr amorphous alloys of different concentrations we established the shape of cluster distribution by sizes, determined the value of percolation threshold p_c, (i. e. the concentration corresponding to formation of percolation cluster) and fractal dimensionality of clusters.

Fr-PB004

LOW FREQUENCY MAGNETOIMPEDANCE IN Co-RICH AMORPHOUS WIRES.

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Low frequency magnetoimpedance effect has been observed in $Co_{68.1}Fe_{4.4}Si_{12.5}B_{15}$ amorphous wires. The wires, with a length of 15 cm and a diameter of 125 mm, were employed in the as cast state, and also subjected to annealing treatments that consist in applying a 500 mA current with a tensile stress of 200 MPa and 400 MPa, during 1 minute. A circular anisotropy developes in the wires after this treatment.

The real and imaginary components of impedance were measured by means of a lock-in amplifier for frequencies in the range between 5 kHz and 110 kHz. A 40 mA rms ac signal passed through the samples during measurements. No hysteretical behaviour has been observed in this frequency range. Resistive component shows a monotonically decrease with changes up to 17.5%/Oe, 13.3%/Oe and 4.1%/Oe at a frequency of 110 kHz for the as cast and 200 MPa and 400 MPa stress annealed wires respectively. The behaviour of reactance shows the dependence of magnetic permeability, through the magnetization processes that take place in this frequency and field range [1, 2].

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163 (1996) 132

Fr-PB005

HARD MAGNETIC PROPERTIES INDUCED IN SOFT AMORPHOUS Co-BASED WIRES

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The devitrification process of amorphous materials leads to the possibility to tailor their magnetic properties in function of applications.
The aim of our work is to provide a wire combining alternative regions having soft and hard magnetic properties along the length of an amorphous CoFeSiB wire with Mo addition.
The study was performed on amorphous wires obtained by the in rotating water quenching technique of composition $Co_{67}Fe_4Mo_1Si_{17}B_{11}$ having 145 μm in diameter, prepared by a rotating water quenching technique. The middle part of the wire was heat treated by current annealing technique, the current being linearly increased.
In the as-cast state the wires present good soft magnetic properties. Current annealing determine an important change in the value of the coercive field, H_c reaching a maximum of about 30KA/m and a slight decrease in the saturation magnetization. The important change in the coercive force is due to the magnetic hardening of this alloy as a result of Mo addition and annealing and originates from the growing crystallites having the size smaller than the correlation length of ferromagnetic exchange interactions.
Thus, we have obtained a $Co_{67}Fe_4Mo_1Si_{17}B_{11}$ wire having alternative portions presenting soft and hard magnetic properties along its length.

Fr-PB006

INFLUENCE OF ANNEALING AND Co ADDITIONS ON THE MAGNETIC BEHAVIOR OF FeCuNbSiB WIRES

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Results on the effect of Fe substitution with different percents of Co on the magnetic behavior of FeCuNbSiB conventional and glass covered wires in the as cast state as well as in different stages of the crystallization process are presented.
We prepared $Fe_{73.5-x}Co_xCu_1Nb_3Si_{13.5}B_9$ (x = 0, 3.6, 7.3, 14.7, 50, 65, 70, 73,5) amorphous glass covered wires, of around 20 μm in diameter and 15 μm thickness of the glass cover by the glass coated melt spinning technique and amorphous wires having around 125 μm in diameter by the in rotating water quenching technique. The samples were isothermally annealed in an electric furnace in Ar atmosphere at 450, 500, 550 and 600°C.
In the amorphous state, the samples having up to 50 at% Co present LBE. For higher Co contents the LBE disappears as a consequence of the reduction in the magnetostrictive constant..
For the samples having up to 50 at% Co he thermal treatments determine the formation of the nanocrystalline state with crystallites of about 20 nm in diameter. This leads to a progressive magnetic softening of samples. The glass covered wires present LBE even after annealing at 550°C. The thermal treatments performed on the samples with more than 50 at% Co lead to an important increase in the coercive field as a consequence of the large size of the crystals that are formed (hundreds of μm), the samples behaving like semi-hard magnetic ones.

Fr-PB007

COHERENT MAGNETIZATION REVERSAL OF Co-BASED MICROWIRES PLACED IN AC LONGITUDINAL MAGNETIC FIELD.

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The magnetization reversal process in amorphous Co-based microwire placed in AC longitudinal magnetic field is studied theoretically. The microwire is supposed to have the circular magnetic anisotropy. The electromotive force frequency spectrum in the pick-up coil wounded around the microwire is described in terms of the coherent magnetization reversal approach. This approach is valid for relatively short samples having a length of the order of one centimeter and lower. The electromotive force frequency spectrum is analyzed as a function of the AC magnetic field amplitude and the longitudinal biasing magnetic field. The analytical expressions for the harmonic amplitudes are found. It is shown that if the longitudinal magnetic field exceeds the microwire anisotropy field, all harmonics appear in the frequency spectrum of the electromotive force. The odd harmonic amplitudes are shown to increase with the AC field amplitude and tend to the constant value, while the even harmonic amplitudes increase with the AC field amplitude, pass over maximum value and than decrease. A high field sensitivity of the harmonic amplitudes is demonstrated. Possible applications of the effect considered are discussed.

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Fr-PB008

THERMAL CONTRACTION AND THE EVOLUTION OF MAGNETIC PROPERTIES OF FINEMET-TYPE PRECURSORS BEFORE AND DURING THE AMORPHOUS-NANOCRYSTALLINE TRANSFORMATIONS

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The thermal contraction is investigated in FINEMET-type precursors during structural relaxation, around the nucleation temperature of nanograin formation (450°C) and at the beginning of nanocrystal formation (520°C) using dilatometric measurements in isothermal and continuous heating mode.
In agreement with the early results [1], an appreciable density increase can be observed well below the nanocrystal nucleation and growth, which is connected with the structural relaxation in the precursor glasses. The increase in density (volume contraction) is continuous during the isothermal heat treatments and reaches to a saturation value at each temperature applied. The saturation value of volume contraction is proportional to the temperature within the range of 350-480°C. The onset of nucleation and the nanograin formation obtained from dilatation measurements will be compared that obtained from the thermomagnetic measurements.

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Fr-PB009

EPR OF Cu $^{2+}$ IONS IN B_2O_3·SrO GLASSES

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Structural properties of strontium borate glasses were investigated by means of the Cu^{2+} ions electron paramagnetic resonance. Glasses of the system $2B_2O_3$·SrO doped with CuO over a wide concentration range were explored to reveal the influence of composition upon the valence state and distribution of copper ions in the glass matrix. The hyperfine structure due to interaction with the I=3/2 nuclear spin was resolved in both parallel and perpendicular bands of the spectra. This reveal a great structural stability of the vitreous matrix when copper accumulates during the doping process, within a relatively broad concentration range. Axially distorted octahedral environments of the Cu^{2+} ions were detected. The lack of clusters of Cu^{2+} ions is another structural characteristic of the investigated glasses. The concentration dependence of the EPR line intensity evidenced the presence of mixed valence states of copper ions, especially at high CuO content. The interactions involving Cu^{2+} paramagnetic ions are predominantly dipole-dipole ones.

Fr-PB010

ELECTRON PARAMAGNETIC RESONANCE ON THE $xV_2O_5(100-x)[P_2O_5{\cdot}Ca]$ GLASS SYSTEM

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Electron paramagnetic resonance (EPR) investigations were performed on samples belonging to $xV_2O_5(100-x)[P_2O_5{\cdot}Ca]$ glass system in the composition range $0.5 \leq x \leq 40$ mol %. The EPR data suggest that for low x values V_2O_5 acts as a glass network modifier while for higher concentratrions ($x \geq 10$ mol %) both P_2O_5 and V_2O_5 behave as glass network formers. On the other hand the results indicate that the symmetry of the vanadyl complex is distorted from O_h toward C_{4v} by increasing addition of V_2O_5 to the [$P_2O_5{\cdot}$Ca glass] matrix
The recorded EPR spectra consist in a superposition of two signals, one with a well resolved hyperfine structure assigned to the isolated V^{4+} paramagneric centers and a second large one assigned to paramagnetic centers associated in clusters. The clustered ions arise due to the dipole-dipole interactions between V^{4+} ions. The size of the clusters increases with the V_2O_5 content of the glass samples as the number of clustered V^{4+} ions denotes in the electron paramagnetic resonance spectra.

Fr-PB011

STRUCTURAL AND MAGNETIC STUDIES OF V_2O_5-B_2O_3-SrO GLASSES

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Electron paramagnetic resonance (EPR) and magnetic susceptibility investigations out between on $xV_2O_5(100-x)[2B_2O_3\cdot SrO]$ glass system with $0 \leq x \leq 30$ mol % were performed. The covalence degree of vanadium bonds was estimated according to LCAO-MO model. The changes observed in the EPR spectra with increase of V^{4+} ions content are explained using a simulation program in the assumption of the superposition of two signals, one with hyperfine structure (hfs) typical for isolated ions and another one consisting in a broad line without hfs characteristic of clustered ions. The EPR data evidence the presence of V^{4+} ions in square-pyramidal coordination (C_{4v}). The progressively disappearance of hfs for high V_2O_5 content suggests the increase of associated ions number coupled by superexchange interactions.
These results are consistent with the magnetic susceptibility data for $x \geq 5$ mol % V_2O_5 where the temperature dependence of the magnetic susceptibility is described by a Curie-Weiss type law with negative paramagnetic Curie temperature. The magnetic susceptibility results also allow the estimation of $V^{4+}/(V^{4+} + V^{5+})$ ratio in the studied samples.

Fr-PB012

MAGNETIC SUSCEPTIBILITY INVESTIGATION OF CaO-Bi_2O_3-GeO_2 GLASSES

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The study of oxide glasses containing cobalt ions evidenced that in function of the cobalt oxide content the cobalt ions can be disposed in sites with octahedral and/or tetrahedral coordination. The corresponding coordination is also reflected by the changes observed in the value of the effective magnetic moment and in the magnetic behaviour of the investigated glass samples [1-3].
In order to obtain more information regarding this problem we investigate a new glass system $xCoO\cdot(1-x)[Bi_2O_3\cdot GeO_2]$ with $0 < x \leq 40$ mol% using magnetic susceptibility measurements in the temperature range 80 – 300 K. The data obtained for the effective magnetic moments of Co^{2+} ions are ranging from 5.23 μ_B for x = 1 mol % to 4.19 μ_B for x = 40 mol % and suggest that at low CoO contents ($x \leq 5$ mol%) the Co^{2+} ions are disposed in octahedral sites while for $x \geq 20$ mol% they occupy tetrahedral sites. In the intermediate composition range (5 mol % < x < 20 mol %) this behaviour is attributed to the statistical average distribution of Co^{2+} ions in octahedral and tetrahedral sites [1-3].
The temperature dependence of the reciprocal susceptibility indicates that the cobalt ions are isolated in samples with $x \leq 5$ mol% and in the samples with higher values of x they participate to negative superexchange magnetic interactions.

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Fr-PB013

STUDY ON DECOMPOSITION OF INTERMETALLIC COMPOUND $Nd_2Fe_{14}B$ UNDER SEVERE SHEAR PLASTIC DEFORMATION

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The influence of severe shear plastic deformation on the structure and magnetic properties (the coercive force, magnetization, ac susceptibility) of $Nd_2Fe_{14}B$-based alloys of $Nd_{11.76}Fe_{82.36}B_{5.88}$, $Nd_9Fe_{84}B_7$, $Nd_{20}Fe_{84}B_{10}$ compositions has been studied. The severe plastic deformation was realized by the torsion between Bridgman anvils under high pressures of 5-10 GPa. The degree of deformation was determined by the angle φ of the rotation from 0.5 to 16 π.
At the initial stage of the deformation ($\varphi < 2\pi$) the intense fragmentation of the grains takes place. Simultaneously, except the main tetragonal phase $Nd_2Fe_{14}B$, additional Fe- and Nd-rich phases appear. The Nd-rich component was observed on the electron diffraction patterns in form of amorphous halo. The Fe-rich component givens wide Bragg's peaks of the bcc phase. The quantities of Fe- and Nd-rich phases increases while the deformation degree grows. The annealing of deformed samples at low and high temperature causes different processes. The annealing at 200 – 500°C causes the coarsening of precipitates of fine non-equilibrium bcc phase and Nd-rich hcp phase. The annealing at T>600^{0}C leads to the synthesis of $Nd_2Fe_{14}B$ intermetallic and, therefore, to the recovery of the starting phase composition.
The work was supported by RFBR, Grant N 98-02-17249.

Fr-PB014

MAGNETOELASTIC BEHAVIOUR OF AMORPHOUS ALLOYS WITH STRIP DOMAIN STRUCTURE.

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ΔE-effect and magnetomechanical coupling factor *k* of the amorphous metal alloy $Fe_{67}Co_3Cr_3Si_9B_{18}$, obtained by the rapidly quenched method, as function of external magnetic field has been investigated. Just before measuring the narrow–stripped specimen were thermal–treated over the range T = $310^0 \div 480^0$C in vacuum 10^{-6} mm Hg. During the treatment the applied field H_{tr}=80 kA/m was perpendicular to the specimen length. Magnetoelastic characteristics of the specimens were measured with the help of the resonance-antiresonance method [1].
At every value of T there were four typical sections on the plots of ΔE-effect vs H and *k* vs H. At H<20÷30 A/m both ΔE-effect and *k* were monotonously decreasing while H increasing. Over the range H from 30 till 50 A/m ΔE-effect and *k* are vanishing. At H> 40 ÷50 A/m there was a growth of the specimens parameters to be measured which lasted till H≈140 A/m, and at H>150A/m a monotonous decrease both ΔE-effect and *k* took place.
As a result, the model, explaining the obtained results on the basis of multi-stage character of domain structure rearrangement in the alloys under investigation, was suggested. The first and the second section of ΔE-effect and *k* vs H are connected with a change of the thin magnetic structure in domains, and third one – with the magnetization rotation towards H - direction, and the fourth one is conditioned by the Bloch-Neel transition of the domain walls structure.
[1] Savage H.T., Clark A.E., Powers L.M., IEEE Trans. Magn., 1975, v.11, pp.1355-1357

Fr-PB015

BASIC PROPERTIES AND POTENTIAL APPLICATION OF $Fe_{60}Co_8Ni_{7.5}Cu_1Nb_2B_{16}$ AMORPHOUS RIBBONS

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The new ferromagnetic amorphous alloy $Fe_{60}Co_8Ni_{7.5}Cu_1Nb_2B_{16}$ produced by rapid quenching from the melt has two main properties: high softness, high resonant magnetoelastic wave amplitude. To optimise these properties a proper isothermal heat treatment is sufficient. When a resonator core is made by short ribbon of this new ferromagnetic alloy, a little change of local magnetising field H can produce an high change of the amplitude A of the resonant magnetoelastic wave; typical values are: $\Delta A/\Delta H \cong 100mV/10A/m = 10^{-2}$ Vm/A. Any magnetic field perturbation of a moving or vibrating object may be therefore detected and, after calibration, the values of the static or dynamic displacement may be measured. If the monitored object is not magnetic, a very little magnetic marker ($\cong 1$ mm^3) may be placed in the point that one wishes to control. In the case of vibration, not only the amplitude but also the frequency spectrum is resolved. Therefore the magnetoelastic wave sensors result competitive with strain gauge, piezoelectric devices or accelerometers. The advantage to operate without contact, namely without disturbing the moving object, is not negligible. The good response of the magnetoelastic resonator is directly dependent on the structural properties of the new ferromagnetic alloy; in particular the optimum homogeneity of the disordered structure and its stability. Ulterior improvement in sensitivity may be obtained by producing an easy magnetisation direction by means of magnetic annealing.

Fr-PB0016

MAGNETOSTATIC PROPERTIES OF Co-BASED AMORPHOUS RIBBONS WITH GMI

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The asymmetry of the giant magnetoimpedance (GMI) in weak-field-annealed Co-based amorphous ribbon was found recently [1]. It depends on the annealing field and the measuring frequency.
To understand the features of GMI we investigated the magnetostatic properties ribbons with different time of annealing (1 - 8 hours) and various magnetic field value (50mOe - 3Oe). The magnetization angle retarding was also measured.
It was found that small magnetic anisotropy in plane of ribbon exists for all samples. The easy magnetization direction has about 30 degree with the axis of the ribbon. After ribbon annealed in magnetic field exceeded 100mOe more than 5 hours the remagnetization become hysteretical in the magnetic field exceeded 10 Oe. The high coercive force fraction is less than 5% of full sample volume. The connection of the magnetostatic properties with the GMI peculiarities is discussed.

[1] Cheol Gi Kim, K.J.Jang, H.C.Kim, and S.S.Yoon // J. of Appl. Phys., 85, (1999), p.5447.

Fr-PB017
MODELING OF ASYMMETRIC GMI PROFILE FOR THE ESTIMATION OF ANISOTROPIES

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Recently, an asymmetric giant magnetoimpedance (GMI) profile, showing GMI-valve phenomenon with the field sensitivity over 1000 %/Oe, has been realized by field-annealing in Co-based amorphous ribbon for high sensitive magnetic sensors[1]. Such a peculiar GMI feature has been qualitatively associated with the role of bias field in B-depleted crystalline layer. The GMI profiles measured at 10 MHz in the sample with annealing field $H_a \leq 50$ mOe shows the nearly symmetric two-peaks behavior. As the annealing field increases above 500 mOe, the asymmetry becomes profound. The GMI peak in negative H, which is antiparallel direction to the annealing field, decreases with H_a, and GMI-valve is revealed.
The numerically obtained profile using single domain model is well fitted to measured one with the suitable parameters of uniaxial and unidirectional anisotropy characteristics. The agreements with the measured profiles for each bias field are shown when the uniaxial and unidirectional anisotropies are 120° and 10° from ribbon axis, respectively, indicating that GMI-valve phenomenon can be realized in the sample with uniaxial anisotropy close to perpendicular direction. It may be reason why we cannot experimentally observe the GMI-valve in Fe-based amorphous. In this paper, we discuss the domain model for asymmetric GMI profile to estimate the characteristics of both uniaxial and unidirectional anisotropies.

[1] C. G. Kim, K. J. Jang, H. C. Kim, S. S. Yoon, J.Appl.Phys., 85, 5447 (1999).

Fr-PB018
EMF MATTEUCCI JUMPS IN ITS FREQUENCY DEPENDENCE

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The ribbons of amorphous alloy $Co_{68}Fe_4Cr_4Si_{13}B_{11}$ ($\lambda_s \sim 10^{-7}$, $H_c \approx 1.2$ A/m, $\mu_o M_s = 0.58$ T) are investigated. They were annealed in strong helical magnetic field that led to appearance of helical magnetic anisotropy [1]. The maximum angles θ_{max} of the easy axes deviations from the ribbon axis are 63°, 44°, 25° and 6°. Measurements of the emf Matteucci dependence from frequency $E_m(f)$ were carried out in magnetic fields of constant amplitude ($H_m = 24$ A/m and $H_m = 20$ A/m).
Dependence $E_m(f)$ is common for all the samples. For frequencies up to 8 kHz $E_m(f)$ has linear character. Its slope increases with augmentation θ_{max}. $E_m(f)$ has maximum with the increase of frequency. After this maximum $E_m(f)$ is different for different θ_{max}. For $\theta_{max} = 63^{\circ}$ $E_m(f)$ goes smoothly to linear dependence with the less slope. The sharp jump of E_m (~100mV) appears for $\theta_{max}=44^{\circ}$ and $\theta_{max}=25^{\circ}$ near f=25kHz. $E_m(f)$ goes to new maximum after this jump.
Behavior of $E_m(f)$ is in qualitative accordance with character of the hysteresis loops of magnetic induction. Form of the loop changes a little at the linear part of $E_m(f)$. The loops narrow after the first maximum of $E_m(f)$. The $E_m(f)$ jumps leads to the loops widening.

0. D.N. Zhmetko, Patent № 2087962, Russia, 1997

Fr-PB019

MAGNETIC ANISOTROPY AND PHASE COMPOSITION OF NANOCRYSTALLINE ALLOY FeCuNbSiB AFTER STRESS- OR MAGNETIC- FIELD ANNEALING

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By method of the Mössbauer spectroscopy the phase composition of specimens of the alloy FeCuNbSiB with different value of magnetic anisotropy constant (K_u) was investigated. The specimens were prepared by nanocrystallising annealing from the amorphous state in the presence of magnetic field or tensile load or without any external action.
It was obtained that the magnetic-field annealing provided maximal K_u values not higher than 400 J/m^3 and the phase composition of the specimens subjected to this treatment did not differ from that of the specimens without IMA. However, the phase content of the stress-annealed specimens was essentially different, but only in the cases of treatments with such tensile loads that resulted in the K_u value higher than 1000 J/m^3. Such a difference may be caused by possible distinctions in the physical origin of the magnetic anisotropy induced by the above treatments.

Fr-PB020

COEXISTENCE OF FERROMAGNETIC AND GLASSY BEHAVIOUR IN HIGH-COERCIVITY $Nd_{50}Fe_{40}Si_{10-x}Al_x$ AMORPHOUS ALLOYS

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The capability to obtain bulk amorphous alloys by mould casting method has recently been extended to the RE-Fe-(Al,Si) (RE = Nd, Pr) systems [1,2]. In order to understand the magnetic behaviour of these kind of alloys we have performed extensive magnetic studies on the $Nd_{50}Fe_{10}Si_{10-x}Al_x$ melt-spun amorphous ribbons with thicknesses up to 150 μm, whose coercivities reach 350 kA/m at room temperature. The differences between the M_{ZFC} (zero field cooled thermomagnetization) and M_{FC} (field cooled thermomagnetization) curves obtained during a regular temperature cycling in different applied fields and also the pronounced cusps that appear on the M_{ZFC} curves indicate a coexistence of ferromagnetic and spin-glass-like behaviour at room temperature. The thick amorphous ribbons present a heterogenous amorphous structure in which are embedded ferromagnetic clusters coupled between them by magnetic exchange interactions. The size and the composition of these clusters can be controlled in the supercooled liquid region by applying thermal treatments on the molten alloys. This characteristic behaviour makes the $Nd_{50}Fe_{40}Si_{10-x}Al_x$ amorphous alloys being interesting for spin dynamics research and also for different applications as recording media or magneto-resistive materials.

[1] Inoue A., Zhang T., and Takeuchi A. // IEEE Trans. Magn., 33, (1997), p. 3814.
[2] Chiriac H., Lupu N. // J. Magn. Magn. Mater., 196-197, (1999), p. 235.

Fr-PB021
STRUCTURAL AND MAGNETIC PROPERTIES OF NANOCRYSTALLINE FeNiMoB PRECURSOR

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Nanocrystalline materials are in the center of interest whether they are FINEMET-based (α-FeSi crystalline grains) or NANOPERM-based (α-Fe crystalline grains). New nanocrystalline materials, based on the FeNi crystalline grains, come out [1].
Magnetic and structural properties of the amorphous $Fe_{40}Ni_{38}Mo_4B_{18}$ alloy that is a precursor of the new nanocrystalls were investigated. The differential scanning calorimetry (DSC) and the temperature dependence of resistivity were used to determine the crystallization temperature. It was shown that amorphous FeNiMoB alloy crystallizes in two steps. Firstly at the temperature 403°C, the FeNi phase appears , secondly FeNiMo borides crystalize at about 500°C. The temperature dependence of the initial susceptibility describes the evolution of the magnetic properties in an amorphous state as well as during nanocrystallization. The Curie temperature was found to be 327°C.
The Magnetic After-Effect (MAE) was investigated, too. The spectrum of MAE consists of thermally activated peak at the temperature 200°C. The activation parameters of the MAE were determined using the computer analysis.

[1] Vojtanik P., Matejko R., Varga R., Sassik H., Groessinger R. // J.Magn.Magn.Mater., 196-197, (1999), 216.

Fr-PB022
THE PROPERTIES OF MAGNETIC NANOSCALED PHASES IN COMPOSITES OF THERMOEXFOLIATED GRAPHITE WITH Ni AND Co

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The magnetic susceptibility $\chi(T)$ of nanocrystaline metal-graphite composite materials with Co and Ni as metallic component was investigated in the temperature range of $300<T<850$ K using the Faraday technique. Under creation of such materials superdisperse thermoexfoliated graphite (TEG) was used. The surface of TEG was modified by Ni and Co using chemical treatment. It was shown that supported metal was distributed uniformly on the surface of particle in the form of separate formations 5-50 nm in size. The magnitude of magnetic susceptibility χ depends linearly on nickel content at T= 300K and its temperature dependence in general is typical for the ferromagnetics. The Curie temperature T_c depends noticeably on concentration of modifier in TEG and decreases with decreasing the concentration of nickel but still it remains lower than for pure bulk nickel. Thus we can make a statement that the nature of such changes in T_c is directly related with the particle sizes L of modifier. In the temperature range $T>T_c$. $\chi(T)$ are well described by the Curie-Weiss law. The paramagnetic Curie temperature θ practically does not depend on Ni content and μ_{Ni} increases with of C_{Ni}, finally approaching the value of $\sqrt{3}\mu_\beta$ which is characteristic of single unpaired d-electron. By contrast to composite with Ni the TEG + Co specimens exhibit $\chi(T)$ behavior that is typical for ferromagnetic amorphous metallic alloys.

Fr-PB023

THE INVESTIGATION OF FeZrB NANOPERM-TYPE METALLIC GLASS

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The magnetic and resistivity properties have been studied for $Fe_{90}Zr_7B_3$ metallic glasses (MG). The samples are industrial ribbons of 16mm width and 30μm thick.

The character of thermomagnetic curve show the studied ribbons to be ferromagnetic at room temperature. But the Curie temperature value ($T_c \approx 310$ K) is only a little higher the room temperature, hence a wide paramagnetic region is observed for as-quenched state. Their paramagnetic susceptibility χ strongly depends on temperature that is caused by the localized moment of Fe atoms. The analysis of $\chi(T)$ curve revealed the following features:

- the reciprocal susceptibility vs temperature is non-linear (the deviating from Curie-Weiss law);
- the rough estimation of the localized magnetic moment per Fe atom resulted in the values exceeding that for pure paramagnetic Fe ($>4.2\mu_B$).

The above features was shown to be attributed to the formation of Fe-rich superparamagnetic clusters, their amount being decreased while sample heating.

The same approach have been successful to discuss the electrical resistivity data. In general electrical resistivity ρ of $Fe_{90}Zr_7B_3$ MG obeyed the common regularities for the disordered systems being described by the improved Faber-Ziman model: for as - quenched ribbon $\rho_{300}=170$ μΩ·cm, $\alpha=1.5\cdot10^{-4}K^{-1}$ and for crystallized ribbon $\rho_{300}=65$ μΩ·cm, $\alpha=1.3\cdot10^{-3}K^{-1}$.

The parameters of FeZrB MG crystallization kinetic have been determined by the Kissinger method and under the isothermal annealing (Avrami equation).

Fr-PB024

ANISOTROPY DISTRIBUTION AND MAGNETOIMPEDANCE IN STRESS ANNEALED AMORPHOUS RIBBONS

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Co-rich stress-annealed amorphous ribbons with transverse inducted magnetic anisotropy have been used recently to correlate domain structure features and magnetoimpedance (MI) behaviour [1].

In this work, we have studied the magnetic anisotropy and magnetoimpedance of stress annealed FeCoCrSiB 20μm amorphous ribbons. Selected heat treatments have been choosed in order to induce at different conditions the magnetic anisotropy with the same value of the anisotropy constant. These samples, showing nearly identical longitudinal quasistatic hysteresis loops, exibit different MI maximum value, MI curve shape, and MI hysteresis.

We explain these results in frame of a simple model assuming, that different distributions of the effective anisotropy is present in samples with different heat treatments.

[1] Kurlyandskaya G.V., Vázquez M., Muñoz J.L., García D., and McCord J.// J.Magn.Magn.Mater., 196-197 (1999), p.259.

Fr-PB025

TORSION MEASUREMENTS USING Fe-RICH GLASS COVERED AMORPHOUS WIRES AS MAGNETOSTRICTIVE DELAY LINE

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The recently developed amorphous magnetic glass covered wires can enlarge the range of applications of amorphous wires [1,2]. This paper presents results concerning the dependence of the response of the $Fe_{77.5}Si_{7.5}B_{15}$ glass covered amorphous wires used as magnetostrictive delay line on the applied torsion. Amorphous wires having 27 μm of the metallic core diameter and 2-6μm thickness of the glass cover were tested in the as-cast state and after current annealing. The response of the delay line (pulsed voltage output) slightly increases when the value of torsion increases up to about 1 rad/m and then decreases. Above a value of the applied torsion of about 8 rad/m the response of the delay line becomes approximately constant. After annealing of the samples, the value of the pulsed voltage output increases. The response curve shapes are nearly independent of the state of the material (as-cast or annealed).
The obtained results suggest the possibility to use Fe-rich glass covered amorphous wires as sensing elements for torsion measurements working on the basis of the magnetostrictive delay line principle. These sensing elements have small dimensions, good sensitivity and very good mechanical and corrosion resistance.

[1] Chiriac H, and. Ovari T. A., Progress in Materials Science, 40 (1996), p.333
[2] Vazquez M., and Hernando A., J. Phys. D: Applied Physics, 29 (1996), p. 939

Fr-PB026

INTERACTION STUDIES IN $Fe_{86}Zr_7Cu_1B_6$ ALLOY SUBJECTED TO DIFFERENT HEAT TREATMENTS

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Amorphous Fe-Zr-Cu-B alloys have inferior magnetic properties resulting from the invar effect. However, these alloys in the nanocrystalline state exhibit excellent soft magnetic properties as well as a high saturation induction equal to about 1.5T. In this paper the data obtained from studies of the magnetic interactions in the $Fe_{86}Zr_7Cu_1B_6$ alloy are presented. These investigations were carried out for the samples in the as-quenched state, for the amorphous samples after annealing at 573K and 673K, and for the nanocrystalline samples containing a different amount of the crystalline phase (after treatments of the amorphous samples at 730 or 800K for 10 s, 1, 10 and 60 min). The amorphous $Fe_{86}Zr_7Cu_1B_6$ ribbons 2mm wide and 15μm thick were produced by a single roller melt spinning technique under an inert atmosphere. From Mössbauer spectroscopy studies it has been found that the amorphous samples in the as-quenched state and after annealing reveal the large component of the magnetization perpendicular to the ribbon surface. However, the magnetization in the nanocrystalline samples is almost randomly distributed. In nanocrystalline samples containing less than 14% of the crystalline phase, the α-Fe grains (above 335K) may be treated as the single domain non-interacting particles. The particle size was determined from magnetization curves and electron microscopy observations. For the higher amount of the crystalline phase the samples exhibit ferromagnetic behaviour.

Fr-PB027

NEW DATA ON PHENOMENON OF AMORPHOUS ALLOYS IRREVERSIBLE CHANGES AFTER LOW-TEMPERATURE TREATMENT

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It was earlier established by us that a structure and all main physical properties (mechanical, thermal, magnetic, optical ets.) of amorphous metallic alloys (AMAs) irreversible change after low-temperature treatment (LTT) [1]. Here we present new data on AMA's magnetic properties in the framework of the above mentioned effect. We have established two necessary conditions for realization of low-temperature effect:

(i) high cooling velocity, which causes large thermo-elasticity stresses ($\sim 10^7$ N/m^2);

(ii) sufficient duration of low-temperature action (≥15 min. for AMAs under study).

Experimental results obtained by magneto-static and quasi-magneto-static methods show that the parameters of the hysteresis cycle depend on alloy's composition, ribbon's geometry and parameters of the LTT (temperature and duration). Fe-based AMAs demonstrate the growth of the saturation induction on 10-15% in comparison with the same for as-quenched AMAs after LTT and a slight decrease of a coercive force (on ≈2%). Co- and Co-Fe-based AMAs show increase of the saturation induction on 8-10% and the decrease of the coercive force after LTT in comparison with the same for as-quenched AMAs. The physical model of LTT phenomena is proposed, which quantitative explains experimental data on irreversible changes of structure and main physical properties including magnetic ones.

[1] Zaichenko S.G., Perov N.S., Glezer A.M. ets., Doklady Physics, **44** (1999) 478.

Fr-PB028

MAGNETIC BEHAVIOUR OF TeO_2-B_2O_3-SrF_2 GLASSES CONTAINING IRON IONS

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Iron ions were used as probes to explore the magnetic properties of the $70TeO_2{\bullet}25B_2O_3{\bullet}5SrF_2$ glasses progressively doped with Fe_2O_3 up to 20 mol %. Magnetic susceptibility measurements performed in the 80-300 K temperature range revealed the changes at concentrations of about 3 mol % Fe_2O_3, from a Curie-type behaviour characteristic to isolated ions, to a Curie-Weiss – type one, with negative paramagnetic Curie temperature typical for superexchange interactions. The distribution of iron ions on different structural aggregates evidenced by EPR measurements and various valence states also depend on Fe_2O_3 content of the glass. Both Fe^{2+} and Fe^{3+} ionic species were taken into account to explain the experimentally obtained values of the molar Curie constant and the effective magnetic moment. Though simultaneously present in glass, Fe^{3+} ions prevail in samples containing up to 3 mol % Fe_2O_3 but the Fe^{2+} ions are prevalent in samples with higher concentrations. The magnetic properties of the investigated system are the result of interactions involving Fe^{2+} and Fe^{3+} ions coupled in simple or mixed pairs.

Fr-PB029

THE ELECTRONIC STRUCTURE PECULIARITIES OF THE Fe-BASED SOFT MAGNETIC MATERIALS

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The method for electronic structure calculation of amorphous materials with the topological disordering accounting is presented. This method is based on the Green's function approach.
The electronic structure of amorphous iron was calculated using the above method. It was shown that the d-band is broaden in 12%, the shape of s- and d-band isn't significantly changed. The electronic spectrum of amorphous Ni was also calculated. Based on these results the magnetic properties and thermal stability of the Fe- and Ni-based amorphous materials are discussed.
The problem of influence of metalloid (B) dopants on electronic spectrum and magnetic properties of amorphous iron is still discussed. We shown that B is acceptor of electrons, as it is presented in [1].
The correlation between the density of electronic states on the Fermi level and the crystallization temperature for the $Fe_{85}TM_5B_{20}$-type (TM are 3d metals) were analyzed. It has been defined that the thermal stability of these alloys is described by the Nagel-Tauc electronic criteria.

[1] Ching W.Y., Yong-Nian X. // Phys. Rev. B, 42, (1990), p.4460.

Fr-PB030

THE USE OF AMORPHOUS ALLOYS WITH IMPROVED MAGNETIC PROPERTIES IN BOREHOLE MAGNETOMETRY

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Measurement conditions and tasks of magnetometric investigations of different geological objects with borehole ferroprobe magnetometers determine specific requirements to these devices and to the material of ferroprobe transducer's cores in particular. The main tasks of our research were :
1. The choice of the most prospective alloys : a) to investigate superdeep boreholes (the depth >12 km) when operating temperature range is (0-275)°C; b) to search hydrocarbon deposits which are the sources of weak geomagnetic anomalies; c) to measure temporal variations of the Earth's static magnetic field when temporal stability of primary measuring converters is important.
2. The study of influence of alloys' treatments to improve an operation of ferroprobe transducers.
It was shown that: a) for borehole magnetic variation stations where high sensitivity and low level of ferroprobe's own noise are required, $Co_{60}Fe_5Ni_{10}Si_{10}B_{15}$ is the most suitable material for the cores of the magnetometer operating at the second harmonic; b) for superdeep boreholes where measurements are carried out in conditions of high temperatures, $Co_{70}Fe_5Si_{15}B_{10}$ is the most acceptable alloy for the above mentioned magnetometer type at present; c) after optimum thermomagnetic treatments $Fe_{60}Co_{20}Si_5B_{15}$ and $Co_{81.5}Mo_{9.5}Zr_9$ are the most prospective alloys for using them as ferroprobe transducer's cores of the magnetometers of a time-impulse type.

Fr-PB031

DESACCOMODATION IN AMORPHOUS ALLOYS WITH SHIFTED HYSTERESIS LOOP

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The time dependence of initial magnetic permeability after demagnetization of toroidal samples of $Fe_{60}Co_{20}Si_5B_{15}$ and $Fe_5Co_{70}Si_{15}B_{10}$ amorphous alloys with different form of hysteresis loop has been studied. It is found that the largest desaccomodation is observed in samples after annealing in DC magnetic field with rectangular shifted hysteresis loops.
The occurrence of shifted hysteresis loops is due to the following mechanisms [1]:

- domain structure stabilization;
- appearance of high coercitive precipitations in the soft magnetic matrix.

It is shown that the prevention of the hysteresis loop shift by means of domain structure destabilization by a high frequency magnetic field annealing decreases desaccomodation of two – three fold.
This work was supported by RFFI (grant 99-02/16279).

[1] Shulika V. V. and Potapov A. P. // J. Phys IV France, 8, (1998), pp. Pr2-147-150.

Fr-PB032

MAGNETIC CORRELETIONS AND SUPERPARAMAGNETIC FLUCTUATIONS IN Co-Nb-Cu-Si-B NANOSTRUCTURES

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Magnetic properties of the multiphase nanocrystalline alloys are mainly determined by the interphase and intraphase magnetic interactions. It is a factor that is dominant up to the Curie point of the matrix which, for the most widely studied Fe-based materials, is far above the room temperature. In the present work we investigate nanocrystalline alloys produced by a partial crystallization of $Co_{66}Nb_9Cu_1Si_{12}B_{12}$ amorphous ribbon. The properties of these samples are peculiar since the Curie temperature of the crystalline phase is about 1000 K whereas the Curie point of their amorphous phase is below 150 K. It enables to study the magnetic behavior of an assembly of strongly ferromagnetic crystallites embedded in a weakly magnetic or paramagnetic metallic matrix, which is the aim of this work. The nanocrystalline samples with small fraction of the crystalline phase have been studied by the saturation magnetization, remanence magnetization, hysteresis loop as well as ZFC and FC magnetization measurements over a wide temperature range (4-1000 K). The results presented show that at elevated temperatures the samples exhibit the superparamagnetic behavior. With decreasing temperature a progressive transition from the superparamagnetism towards a collective state occurs and it is the best seen close to the Curie point of the amorphous matrix. At low temperatures the magnetic state of the samples results from a competition between the strength of grain-matrix exchange interactions and the effective anisotropy of individual grains. However, in the material with weakly magnetic matrix, the anisotropy effects of randomly oriented grains are dominant. The experimental results are supported by the micromagnetic modeling of the nanostructures considered.

Fr-PB033

ECAP PROCESSING, MICROSTRUCTURE AND HYSTERETIC PROPERTIES OF ULTRAFAIN GRAINED $Pr_{20}Fe_{73.5}B_5Cu_{1.5}$ – ALLOY

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Severe plastic deformation (SPD) by shear is an effective method of formation of ultrafine-grained (UFG) structure and attractive properties in metals and alloys. The torsion straining under high pressure of R-Fe-B alloys (R – Nd, Pr) results in formation of nanostructured state with high level of coercivity [1]. However, for practical application more effective method of SPD technique is equal channel angular pressing (ECAP). This method allows to fabricate bulk samples with UFG structure in pure metals and single phase alloys. The ECAP for low-plastic multiphase R-Fe-B alloys is a complex technological problem and it hasn't been used yet. The present work is devoted to investigation of the possibility of ECAP of homogenized cast $Pr_{20}Fe_{73.5}B_5Cu_{1.5}$ alloy in order to fabricate UFG structure and high coercitive state. The influence ECAP parameters on the structure and properties were studied during SPD. After deformation the bulk samples were obtained. Microstructure of the deformed ingots refines very much, that results in coercitivity rise up to 15-16kOe. ECAP forms in samples magnetic texture of "easy plain" type.

The work was supported by RFBR, Grant # 98-02-17249.

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Fr-PB034

CRYSTALLIZATION AND MAGNETIC CHARACTERISTICS OF $Fe_{85.4}Zr_{6.8-X}Nb_XB_{6.8}Cu_1$ (x=0, 1 or 2) ALLOYS

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Fe-Zr amorphous alloys exhibit a complex magnetic behaviour and their magnetic properties strongly depend on Zr concentration. It has been found that the crystallization of the amorphous Fe-Zr-B-Cu alloys leads to the nanocrystalline materials consisting of α-Fe fine grains and the amorphous matrix. In this paper the effect of replacing Zr atoms by Nb atoms in the $Fe_{85.4}Zr_{6.8}B_{6.8}Cu_1$ alloy on the crystallization temperature, α-Fe grain size, composition of the crystalline phase and amorphous matrix is studied. The crystallization temperature was determined from DSC and magnetization curves. The grain size was estimated from electron microscope observations (HREM) and X-ray diffraction patterns. However, the phase composition of the nanocrystalline samples was determined from Mössbauer spectra analysis. Additionally, the structure sensitive magnetic properties such as the magnetic susceptibility and its disaccommodation for amorphous and nanocrystalline samples in the temperature range from 150 up to 350 K were investigated. It is stated that the replacing Zr atoms by Nb atoms in the $Fe_{85.4}Zr_{6.8}B_{6.8}Cu_1$ alloy causes the decrease of the crystallization temperature. Moreover, HREM observations show very fine α-Fe grains in the as-quenched amorphous $Fe_{85.4}Zr_{4.8}Nb_2B_{6.8}Cu_1$ sample. That is also confirmed by Mössbauer spectroscopy investigations. As for disaccommodation of the amorphous samples, its intensity decreases with Nb content.

Fr-PB035

ASYMMETRIC TORSION GIANT IMPEDANCE IN NEARLY-ZERO MAGNETOSTRICTIVE AMORPHOUS WIRES WITH INDUCED HELICAL ANISOTROPY.

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The effect of the torsion strain on the electrical impedance in $(Co_{0.94}Fe_{0.06})_{72.5}B_{15}Si_{12.5}$ amorphous wire with induced by torsion current annealing helical magnetic anisotropy has been investigated. The torsion stress impedance ratio, $\Delta Z/Z$, has been defined as:

$$(\Delta Z/Z)_{\xi}\,(\%) = [(Z(\xi) - Z(\xi_{max})]\cdot 100/\, Z(\xi_{max})$$

where the maximum torsion used, ξ=65 rad/m, was considered as ξ_{max}.

An asymmetric character of the $(\Delta Z/Z)_{\xi}$ dependence with a broad maximum at around 20 rad/m has been observed in as-cast state where $(\Delta Z/Z)_{\xi}$ =170%. Joule heating at current of 450 mA for duration till 105 min and under torsion, ξ, till 33 πrad/m significantly modifies the $(\Delta Z/Z)_{\xi}$ dependence. After Joule heating $(\Delta Z/Z)_{\xi}$ has a tendency to achieve finally sharp and more asymmetric shape with a sharp maximum at certain torsion, ξ_m. Maximum $(\Delta Z/Z)_{\xi}$, ratio of 330% is obtained after optimal conditions of current annealing under torsion and ξ_m increases with the torsion applied during current annealing, ξ. The asymmetry of the $(\Delta Z/Z)_{\xi}$ in as-cast state and after torsion annealing could be ascribed to the spontaneous or induced (after torsion annealing) helical anisotropy, which can be compensated by the application of certain torsion stress.

Fr-PB036

REVERSIBLE AND IRREVERSIBLE CHANGES OF MAGNETIC CHARACTERISTICS IN AMORPHOUS AND NANOCRYSTALLINE SOFT MAGNETIC ALLOYS UNDER ACTION OF γ-IRRADIATION

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The influence of hard γ-irradiation (^{60}Co with energy of γ-quantums 1.2 MeV, irradiation doze ~$2\cdot 10^8$R) on dynamic (1kHz) magnetic properties of toroidal cores from amorphous (MG) and nanocrystalline (FM) alloyed alloys of Fe-Si-B system has been studied. Chemical composition of MG alloys was varied in the range 75.5÷78.5 at% Fe, 18.0÷20.0 at% (Si+B) and 1.5÷6.5 at% (Ni+Mo). Content of Fe in FM alloys was 70.05÷73.6 at%, (Si+B) – 23.0÷25.4 at%, Nb – 1.95÷3.0 at%, Cu – 1.0 at%, Co – 1.55at%.

It has been shown that, depending on chemical structure of MG- and FM-alloys, irradiation of annealed cores causes both reversible and irreversible effects of change of their magnetic characteristics in time.

For low contents of Ni (up to 1 at %) and Mo (up to 0.5 at %) in amorphous alloys and for 1.9-2.25at% Nb in nanocrystalline alloys values of amplitude magnetic permeability μ_1, μ_{max} and the half-width of reverse magnetization dynamic loop H_c after γ-irradiation are not restored during long time exposures without additional thermal effect.

For irradiated cores from alloys with increased contents of Ni, Mo and Nb the return in time of μ_1, μ_{max} up to values characteristic of not irradiated alloys has been established.

As a result of investigations it has been determined the most radiation-resistant compositions of amorphous and nanocrystalline alloys.

Fr-PB037

NEW SOFT MAGNETIC AMORPHOUS Co-BASED ALLOYS FOR FERROSONDE SENSORS OF MAGNETIC FIELD

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New high permeable cobalt alloys (Co-Si-B base system) are created and the technology of manufacturing from them high-quality amorphous ribbons with thickness ~ 25 μm by melt spinning method is developed.
Toroidal magnetic cores made from Co_{65} (Fe, Cr)$_6$(Si, B)$_{29}$ and $Co_{65.5}$(Fe, Cr)$_{6.5}$(Si, B)$_{28}$ alloys after additional heat treatment are characterized by considerably smaller field of reaching maximum magnetic permeability, and also have higher dynamic initial μ_0 and maximum μ_{max} permeability in combination with smaller coercive force H_c in wide frequency range in comparison with 81NMA permalloy.
$Co_{65.5}$(Fe, Cr)$_{6.5}$(Si, B)$_{28}$ alloy has $\mu_0 > 200000$, $\mu_{max} > 400000$ and $H_c \approx 0.15$ A/m at frequency 1 kHz. At value μ_0 comparable with permalloy rolled up to thickness 50 μm Co_{65}(Fe, Cr)$_6$(Si, B)$_{29}$ alloy is characterized by $H\mu_{max} \approx 0.6$ A/m (for 81NMA –1.6 A/m), and at that it's saturation induction $B_S \leq 0.25$ T, that is twice lower than values B_S for permalloy.
The level of magnetic characteristics of new economically doped alloys allows to use them effectively instead of 81NMA and 83NF permalloys as magnetic cores of highly sensitive ferrosonde sensors during measurements of small magnetic fields during carrying out aerospace and geophysical researches.

Fr-PB038

EFFECTIVE ANISOTROPY AND MAGNETIC PROPERTIES OF SMALL PARTICLES OF HEXAGONAL FERRITE

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The different dispersion degree dusts systems of unreplaced hexagonal ferrite at M-type structure are researched with the methods of simultaneous gamma-, x-ray, electronic Mössbauer spectroscopy (SGXEMS) coupled with magnetic measurement set. It is shown that the nano-chips magnetic structure is dislocated and magnetic moments in near-surface layer are turned down from a hexagonal axis *c*. The magnetization isotherms possess the peculiarity of jumping in fields of $H \sim 0.6H_a$ at $T > 300$K. The contribution of a "surface" anisotropy to an effective anisotropy of particles is essential only for particles of nanometre range. The K_s "surface" constant as well as magnetic crystallographic anisotropy constant K_1 has the same order, but opposite on the sign ($-1.8 \cdot 10^6$ erg·cm^{-3} and $+ 3.3 \cdot 10^6$ erg·cm^{-3} at 300K, accordingly).
Possibly, the observable anomalies are followed from stackening of exchange interaction and *M*-ferrite interactions shaped with magnetic crystallographic anisotropy of including gaps of interionic connections, their deformations and changes of a local symmetry of crystallographic positions of iron ions in near-surface layers. The model is developed to identify a constant K_s as a constant K_2 in decomposition of an anisotropic part of a thermodynamic Gibbs potential. The anomalous magnetization isotherms are theoretically justified, and the occurrence of "taper" of the magnetic moments in near-surface layers of *M*-type ferrite nano-particles is explained.

Fr-PB039

FEATURES OF THE MAGNETIC STRUCTURE AND MAGNETIC STATE OF SMALL PARTICLE SYSTEM

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The formation mechanisms of magnetic properties of small particle systems of a highly anisotropic uniaxial ferrimagnet have been investigated. On the $BaO \cdot 6Fe_2O_3$ nanocrystals as an example are cleared up the roles of the size factor and the crystal surface in this process. In the (H-T) diagram obtained in the range 4.2K-T_c an extended in temperature and field region of magnetically unstable superparamagnetic state is found. A number of regions with states not characteristic of macroscopical object has been also revealed. These are regions attributed by the distributions in anisotropy fields and the perturbation of the collinear magnetic structure of nanoparticles. It has been shown that the existence of the near-surface region of 2-3nm thick with a "canted" magnetic structure in the highly anisotropic crystals is caused by the two competing mechanisms of anisotropy, namely, the magnetocrystal and "surface" anisotropy. The constant of the latter is negative and comparable in magnitude with that of magnetocrystal anisotropy.

Fr-PB040

MAGNETIZING OF AMORPHOUS Fe-B ALLOYS: ELECTRONIC STRUCTURE AND LOCAL ANISOTROPY

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The magnetization of metallic glasses $Fe_{1-x}B_x$ (x=0.14, 0.16, 0.17, 0.20) of near eutectic compositions has been investigated at temperatures 10-300 K in magnetic fields 0.1-40 Oe under longitudinal mechanical tension stresses of 0-68 MPa. It is revealed, that the susceptibility χ, describing the initial magnetization curve, may be represented by an interpolation formula $\chi = \chi_0 \cdot \left[1 + \xi \cdot \tanh(H/H_d)^p\right] / \left[1 + (H/H_a)^q\right]$ in the main fields region of technical magnetizing mechanisms changing (0-15 Oe). In the region of rotation processes 16<H<40 Oe the best fit of experimental data was given by $\chi = 0.5 / D \cdot (M_s/H)^{1.5}$. Parameters χ_0 (initial susceptibility) and D (local anisotropy parameter) well correlate with the conduction electrons density [1], and thus confirm the assumption about the changing of electron configuration of Fe ions in alloys from Fe^{3+} to Fe^{2+} for the eutectic alloy (x=0.17). The χ value and the sensitivity of magnetic parameters to the mechanical stresses depend on the alloy composition. They are the biggest for the threshold alloy (x=0.16), as well as their dependence on temperature, and they are the smallest for the eutectic alloy, possessing a special stable electron structure.

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Fr-PB041

MAGNETIC PERMEABILITY OF CAST AMORPHOUS MICROWIRE

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In present work we report results of investigation of static and high frequency magnetic properties of amorphous microwires. Glass-covered amorphous microwires have been obtained by Taylor-Ulitovsky's technique. We will show the conditions of obtaining maximum magnetic permeability in this article.
Permeability at high frequency was measured by the resonance method. We are interested in magnetic properties of amorphous microwires with the close to zero negative magnetostriction constant and the effect of applied external stress on these properties. At high value of negative magnetostriction, the shape of reversal magnetization presents flat non-hysteresis loop.
Experimentally we obtained large values of magnetic permeability in amorphous magnetic microwire, which remain large up to high frequencies.

Fr-PB042

HARD MAGNET Nd-Fe-B: ELASTIC STRESSES AND MAGNETIC ANISOTROPY

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Temperature dependence of magnetic remanence of the sintered magnet with general formula $Nd_{18}Fe_{71}B_8M_3$ ($M_3 \approx Pr_{1.1}Tb_{0.7}Dy_{0.6}Ti_{0.4}Nb_{0.2}$), prepared by powder metallurgy method, has been measured at temperatures 4.2-300 K. The temperature dependence $\theta(T)$ of the angle between magnetization vector and c-axis in crystallites of the main magnetic phase $Nd_2Fe_{14}B$, as well as spin reorientation temperature T_s, were found using the experimental data and calculations in the framework of two-sublattice (Nd-Fe) molecular field model and the 2nd order phase transitions theory.
It has been found, that θ_{max}=43° and T_s=140 K. It means, that θ_{max} as well as T_s are ~ 10° and 10 K higher, respectively, than it could be expected taking into account effects of substituting impurities on the characteristics of $Nd_2Fe_{14}B$ single crystal [1].
We suppose, that the found effect is caused by the internal stresses in the grains system of $Nd_2Fe_{14}B$ and nonmagnetic phases (about 25 volume %) of the sintered sample, which give the substantial magnetoelastic contribution into the magnetic anisotropy constants K_1 and K_2 ($\Delta K_1 \sim -0.8 \cdot 10^7$ erg/cm^3 at 5<T<130 K, $\Delta K_{1max}/K_{1max} \sim 0.1$, $\Delta K_{2max} \sim -7.56 \cdot 10^7$ erg/cm^3, $\Delta K_{2max}/K_{2max} \sim -0.5$), that exceeds the effect of impurities.

[1] Lin C., Lin Z.-X., Sun Y.-X., Bai C.-X., and Zhao Z.-S. // Phys. Rev., B39, (1989), p.7273.

Fr-PB043

OPTIMIZATION OF PERMANENT MAGNET SYSTEMS FOR MICROWAVE ELECTRONICS AND NMR APPLICATIONS

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Present rare earth permanent magnets (Ne-Fe-B, Sm-Co) permit to design energy-independent magnet systems (MS) with a desired characteristics of magnetic field. In many cases an application of soft magnetic elements (SME) allows to decrease considerably the weight of MS and to form the desired distribution of magnetic field. In this case it is necessary to solve the optimization problem for permanent magnet alongside with the SME problem.

A general approach to the synthesis of optimal MS from hard magnets and SME has been described. The mathematical problem has been reduced to the extremum search under constant volume. The optimization program based on the application of surface integral equation method has been developed to determine construction of MS. A given criterion was the minimum of the magnetic field inhomogeneity for NMR systems and the maximum of the magnetic field and the minimum of its inhomogeneity for microwave electronics MS.

The method developed has been used for the design of optimal MS for microwave electronics: (a) relativistic backward wave tube and (b) for NMR application. The experimental MS's with following parameters have been produced:

(a) working stepped channel diameter: 12-50 mm, length of homogeneous field region (inhom.<3%): 40 mm, flux density: 1.45 T, weight: 22 kg.

(b) the field inhomogeneity for the volume of diameter 30-40 mm - 10^{-3}-10^{-4}, field strenghth: from 200 to 2000 Oe, weight: 6-10 kg.

Fr-PB044

PECULARITIES OF ANISOTROPIC STRUCTURE AND PROPERTIES OF STRONTIUM HEXAGONAL FERRITES SYNTHESIZED FROM INDUSTRIAL WASTES

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The research analysed the pecularities of anisotropic structure formation and magnetic properties of hexagonal ferrites synthesized from mixtures of iron oxides, strontium, and ready ferrite $SrFe_{12}O_{19}$. The pecularities of ferrite formation processes are investigated for the analysed system for different temperature intervals. It is found out that diffusion mobility of oxyden and strontium ions play an important role in ferrite formation. The newly formed ferrite crystals are almost randomly oriented in magnet.

After exposition at the temperature of 1200-1250°C, it is possible to obtain anisotropic magnets with a small reorientation angle of crystallites. Their texture parameter most intensively increases after the mixture ferritization process is completed. Absolute values of this parameter depend on the contents of ready ferrite $SrFe_{12}O_{19}$ in the mixture of oxides. The main process which contributes to texture formation is recrystallization and crystallite turn (rotation). The correlation between reorientation angle of crystallites and magnetic properties of magnets is established. Optimal values of magnetic parameters (H_{CB} = 220 kA/m, B_r = 0.42 T) and texture parameter were obtained for magnets synthesized from mixtures with 40% (by weight) of ready ferrite $SrFe_{12}O_{19}$.

The data obtained serve as a basis for developing a technique of one-stage-manufacturing of permanent magnets.

Fr-PB045

MICROSTRUCTURE AND MAGNETIC PROPERTIES OF THE Sm-Fe-N MAGNETS PRODUCED BY DIFFERENT METHODS

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The studies were carried out on the Sm-Fe-N magnets produced applying different manufacturing methods, i.e.: (i) HDDR process, (ii) mechanical milling, (iii) melt spinning and (iv) mechanical alloying. Magnets were nitrogenated at temperature 750 K for 3 hours. X-ray and Mössbauer spectroscopy, as well as microstructural observations were carried out for all samples. Moreover, coercivity, remanence and energy product $(BH)_{max}$ were determined in dependence of the manufacturing process and applied heat treatment.
In particular, Mössbauer spectroscopy results show that concentration of the magnetic hard $Sm_2Fe_{17}N_3$ phase is much higher in the magnets after HDDR process (89.0%) than for magnets after mechanical milling (56.7%). However, this phase concentration remains constant at the level 85% for magnets after melt spinning and mechanical alloying. Additional phase – $SmFe_7$ was detected in the magnets after mechanical milling, melt spinning and mechanical alloying. The best magnetic properties were achieved for the magnets consisted of magnetic hard $Sm_2Fe_{17}N_3$ phase and magnetic soft α-Fe and $SmFe_7$ phases. Such structure was obtained in samples produced using method of melt spinning and mechanical alloying.

Fr-PB046

MICROMAGNETIC STRUCTURE AND MAGNETISATION REVERSAL PROCESS IN Nd-Fe-B PERMANENT MAGNETS

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A modified boundary element method [1] for the calculation of 3d magnetic fields in a volume of Nd-Fe-B permanent magnets with different micromagnetic structures was used. The distribution of the local demagnetizing fields for the individual grains was calculated and determined using domain structure observations [2]. The effect of the stray field of surrouding grains on the nucleation field H_n has been estimated quantitatively. It is found that changes in H_n of individual grains of 0.5 T may be observed, depending on the micromagnetic state of neighbouring grains.

[1] Christoph V., Töpfer J. // Proc. of the 15-th Workshop on REM and their Appl., Dresden, (1998), p.861.
[2] Pastuschenkov Yu.G., Dyogteva O.B., Shipov A.W., Skokov K.P. // J. Magn. Magn. Mater., 157/158, (1996), p.67.

Fr-PB047

THE MAGNETIC AND STRUCTURAL PROPERTIES OF MECHANICALLY MILLED NANOCOMPOSITES BASED ON $Nd_{3.25}Tb_1Fe_{72.75}Co_5B_{18}$

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The coercivity of mechanically alloyed nanocomposites of $Nd_{4.25}Fe_{77.75}B_{18}$ ($H_c = 175$ kA/m) was improved by 22% by the substitution of 1 at% heavy rare-earth and 5 at% Co for Fe; $Nd_{3.25}Tb_1Fe_{72.75}Co_5B_{18}$ ($H_c = 213$ kA/m). This composition was then systematically varied in an attempt to further increase the magnetic properties and gain a better understanding of the coercivity mechanism.

The Mössbauer spectrum for the as-milled $Nd_{3.25}Tb_1Fe_{72.75}Co_5B_{18}$ powder is fitted with subspectra fitted for $(Fe,Co)_2B$ (~15 wt%), α-(Fe-Co) (~6.6 wt%), and an amorphous phase rich in boron and poor in Nd with an average hyperfine field of 23.8 T (74 wt%) and an unidentified phase, containing ~5% of the Fe atoms with a hyperfine field of 19 T. The Mössbauer spectrum and X-ray diffraction patterns for the annealed powders revealed that new phases ($Nd_2Fe_{14}B$ and $NdFe_4B_4$) present resulted in the samples becoming magnetically hard.

The rare-earth components were varied in order to increase the magnetocrystalline anisotropy of the hard phase, Nd for Tb, Dy for Tb and Pr for Nd. The optimum coercivity was achieved for $Pr_{3.25}Tb_1Fe_{72.75}Co_5B_{18}$ with a H_c of 250 kA/m. Further additions of Si, Ti, $Cu_{0.5}Nb_{0.5}$, Cr and Fe were used to enhance the magnetic properties to give a sample $Nd_{3.25}Tb_1Fe_{71.75}Co_5Cu_{0.5}Nb_{0.5}B_{18}$ with a remanence of 1.11 T, coercivity of 264 kA/m and an energy product of 75 kJ/m^3. The rare-earths substitute into the hard magnetic phase, $R_2Fe_{14}B$ but Co was found to substitute mainly into the α-(Fe-Co) and $(Fe,Co)_2B$ soft phases from a series of high temperature AC susceptibility measurements.

Fr-PB048

ANISOTROPIC BONDED $Sm_{2.3}Fe_{16.8}Zr_{0.2}N_x$ MAGNETS PREPARED BY MILLING OF AS CAST MATERIAL

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Recently, it was shown that a small addition of only 1 at% Zr impedes the formation of α-Fe in as-cast Sm_2Fe_{17}. Magnets prepared from non-homogenized $Sm_{2.3}F_{16.8}Zr_{0.2}N_x$ ($x \approx 3$) by means of ball milling prior to nitrogenation exhibited excellent magnetic properties [1]. In this work, the dependence of the magnetic properties on the milling time is presented in detail. The $Sm_{2.3}F_{16.8}Zr_{0.2}$ powders were milled for 100 min $\leq t \leq$ 900 min. After annealing at 800°C for 1 h and subsequent nitrogenation, the samples were cold compacted in a magnetic field and resin bonded. The coercivity $\mu_{0J}H_C$ of the samples increased from 0.8 T for t = 100 min to 2.3 T for t = 900 min. On the other hand, the remanence of the easy magnetization direction decreased monotonically with increasing milling time due to the decrease of texture of the aligned powders. Prolonged milling refines the microstructure on the cost of the degree of anisotropy of the powder and finally it leads to the formation of a soft magnetic phase as indicated by a shoulder in the demagnetization curve for t > 600 min. The highest energy product $(BH)_{max}$ of 50 kJm^{-3} (136 kJm^{-3} for the theoretical density of 7.7 gcm^{-3}) was obtained for an intermediate milling time of 400 min. Comparative studies using Zn bonded magnets resulted in lower energy products but improved coercivites.

[1] B. Gebel, M. Kubis, and K.-H. Müller, J. Magn. Magn. Mater. 174 (1997) L1.

Fr-PB049

MICROSTRUCTURE, MAGNETIC AND MECHANICAL PROPERTIES OF MAGNETS FROM Nd-R-Fe-Co-B TYPE ALLOYS

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It is well known, that for the remanence temperature stability improving in the Nd-Fe-B type magnets, a some amounts of Nd and Fe in the basic alloy must be substituted by a heavy rare-earth and Co respectively [1]. However, such substitutions increase the magnets brittleness and so, the reasons of it demand the special investigation.
In this work the magnetic and mechanical properties of sintered magnets prepared from the Nd-Ho-Fe-Co-B alloys with 0, 10, 20 and 30% Co content (with respect to Fe) as well as their microstructure peculiarities have been studied. The X-rays, SEM and TEM methods were used for phase analysis and macro or micro stresses determination in magnet bodies.
It was shown, that the Co introduction gives the lowering of ultimate compression strength value from ~1000 MPa (for Co-free magnets) to ~ 600 MPa (at 30% Co) and the character of magnets destroying changes from the inter-crystalline to the trans-crystalline one. This correlates with the macro stress value in magnet body which is at approximately zero level in the pure Nd-Fe-B and is negative in Co-substituted magnets. The search of an additive elements to the alloys improving the ultimate strength was made and these results will be presented also in the report.

[1] Shigehiko A., Tsugio S.// IEEE Trans. on Magn., 21, (1985), p.1952.

Fr-PB050

NANOSTRUCTURE AND MAGNETIC PROPERTIES OF Nd-Fe-B MELT-SPUN RIBBONS CONSOLIDATED BY SEVERE DEFORMATION

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Bulk samples of nanocrystalline Nd-Fe-B system alloys of different composition were produced by unconventional compacting technique such as severe plastic deformation consolidation of melt spun ribbon powders at room temperature. This processing method itself does not insert any contamination and the samples practically have no residual porosity.
Microstructure investigations by means of transmission electron microscopy did not reveal significant grain growth in consolidated samples in comparison with initial as-quenched state.
At the same time, however, magnetic measurements show significant deterioration of the properties of the as-consolidated samples. X-ray analysis points to partial decomposition of the main phase and increase of the volume fraction of the phase based on α-Fe in this structural state. Subsequent annealing leads to restoration of magnetic properties, caused primarily by returning to original phase composition.

Fr-PB051

OPTIMALISATION OF PREPARATION OF SUBSTITUTED Ba FERRITES

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Hexagonal barium ferrite substituted by cobalt and titanium has been prepared from the soluble nitrate salts of barium and iron with citric acid and ethyleneglycol [1,2]. Dehydration was performed through the long time vacuum drying as well as through the liquid drying in ethylalcohol [3]. The initial Ba/Fe ratio was varied and x = 0.5 ion/f.u. additions of Co and Ti has been used. To obtain the required ferrite composition a cumulative thermal treatment as well as a treatment in a microwave oven was performed.
The single phase hexagonal structure was obtained at the temperature treatment below 1000°C during 10 minutes when microwave heating was used. For the process verification Mössbauer spectroscopy and magnetic measurements were applied.
The final $BaCo_{0.5}Ti_{0.5}Fe_{11.0}O_{19}$ had specific magnetic polarisation J_S = 120 $mTcm^3g^{-1}$, coercivity H_C = 85 kAm^{-1} and Curie temperature 390°C.

[1] Grusková A. et al.: Journal of Magnetism an Magnetic Materials 101 (1991) pp. 227-229
[2] Michalíková M. et al.: IEEE Transactions on Magnetics, Vol. 30, No. 2 (1994) pp.654-656
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Fr-PB052

ON THE REVERSIBLE MAGNETIZATION BEHAVIOR IN TWO PHASE NdFeB BASED MELT SPUN RIBBONS

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The present paper presents the magnetic properties of some two-phase $Nd_2Fe_{14}B/\alpha Fe$ melt spun thin ribbons (t=25μm): $Nd_4Fe_{86}CuNb_3B_6$, $Nd_8Fe_{82}CuNb_3B_6$, $Nd_8Fe_{77}Co_5CuNb_3B_6$ and $Nd_8Fe_{78}Co_5Hf_3B_6$, with different volume ratio of the $Nd_2Fe_{14}B$ hard magnetic phase. The reversible behavior of the magnetization is investigated by δM plots and irreversible susceptibility $\chi_{irr}(H)=dM_d(H)/dH$ (M_d demagnetization remanence) plots. This behavior is close related to the intergrain exchange interactions which are found to be preponderant in samples with a higher volume ratio of the hard magnetic phase due to some peculiarities of the structure induced during the specific crystallization process. A single sharp peak in the profile of the irreversible susceptibility $\chi_{irr}(H)$ indicates a well coupled system in the case of the samples with Co and a higher Nd content whereas a broad peak or a profile with two peaks for the other samples denotes a two distinct phases with a low level of the magnetic coupling. The difference of 48% between the value of the nucleation field of the reverse domains H_n= 198kA/m and coercive force ${}_iH_c$=95kA/m along with a double peak of $\chi_{irr}(H)$ was found in the samples with the highest volume ratio of the soft phase (about 72vol% for $Nd_4Fe_{86}CuNb_3B_6$ samples annealed at 750°C for 5 min). All samples behave as exchange-spring magnets, the recoil permeability increasing with increasing the soft / hard volume ratio (e.g. from $\mu_{rel\ rec}$=0.8 for $Nd_8Fe_{77}Co_5CuNb_3B_6$ to $\mu_{rel\ rec}$=1.7 for $Nd_4Fe_{86}CuNb_3B_6$ treated at 750°C for 1 min.). Magnetic properties and reversible behaviour of the magnetization revealed by $Nd_2Fe_{14}B/Fe_3B$ thick ribbons (t=100μm) with the exact composition $Nd_8Fe_{73}Co_5Hf_2B_{12}$ are comparatively presented.

Fr-PB053

PHASE TRANSITION STUDY OF IRON-PLATINUM ALLOYS

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The temperature dependence of the real part of the ac-susceptibility of some compounds based on almost equi-atomic Fe-Pt alloys has been studied. The fcc - fct structural phase transition can be observed in-situ during the heat treatment. We studied also the dynamics of the transformation by applying different heating rates. The results will be discussed in terms of the relation with some other dc magnetic measurements and X-ray studies.

Fr-PB054

ON ELEMENTARY EXCITATIONS IN MAGNETOPLUMBITE-TYPE STRUCTURES

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Hexagonal ferrites of magnetoplumbite-type structure and related materials are of the great interest either for fundamental research, or for numerous prospective applications like permanent magnets or low-temperature co-fired functional materials. We perform a comprehensive symmetry analysis of their magnetic ordering and calculations of their vibrational and magnetic resonance spectra. The conditions of mode excitations are studied, and the dependencies of magnetic resonance frequencies on magnetic field are obtained with the special emphasis on the exchange modes which are magnetic analogue of optical phonons. We have paid attention to the investigation of modes within submillimeter and far infrared regions. Effects of doping have been studied with respect to available experimental data.

Fr-PB055
ANALYSIS OF MAGNETIZATION PROCESSES IN 3% SiFe FROM COMPLEX SUSCEPTIBILITY SPECTRUM

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In this paper, we propose phenomenological model for the reversible complex susceptibility spectra of 3% SiFe ribbon, considering Debye-type relaxation processes of reversible domain wall motion and reversible magnetization rotation, as follows:

$$\chi^*_{rev}(f)=\chi_\infty+\chi^*_{dw}(f)+\chi^*_{rot}(f)=\chi_\infty+\left(\frac{\chi_{dw}}{1+(f/f_{dw})^2}-j\frac{\chi_{dw}(f/f_{dw})}{1+(f/f_{dw})^2}\right)+\left(\frac{\chi_{rot}}{1+(f/f_{rot})^2}-j\frac{\chi_{rot}(f/f_{rot})}{1+(f/f_{rot})^2}\right) \quad (1)$$

where χ_{dw} and f_{dw} are static permeability and relaxation frequency of reversible domain wall motion, χ_{rot} and f_{rot} those of reversible magnetization rotation. A rectangular samples (0.03 cm thick, 1.5 cm wide, and 12 cm long) with cut angles α =0° and 90°, relative to the [001] direction, were prepared from a commercial 3% SiFe sheet. The frequency spectra of relative complex susceptibility $\chi^*=\chi'-j\chi''$ were measured by using HP4192A impedance analyzer with a solenoid coil wound around the samples. We decompose the measured spectra into domain wall and magnetization rotation components in Eq.(1). The effects of longitudinal stress and laser scribing on magnetization processes of 3% SiFe are analyzed from the decomposition method.

[1] S.S. Yoon, C.G. Kim, I.Y. Kim, S.D. Kwon and H.C. Kim , J. Appl. Phys. 85, 6028, 1999.

Fr-PB056
HIGH PRESSURE INDUCED NEW MAGNETIC PHASE IN Gd_2CuO_4

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In the present work the investigations of high pressure influence on the magnetic ordering in quasi-two-dimentional magnets with the chemical formula R_2CuO_4 [1] was continued. The behavior of initial radiofrequency magnetic susceptibility (ν=1MHz) in Gd_2CuO_4 which characterized by a set of phase transitions [2] has been studied. The following main results were obtained: (1) Hydrostatic pressure leads to the increase of magnetic ordering temperature of Cu-sublattices with the baric coefficient $dT_N(Cu)/dP \approx 0{,}15$ K/kbar. (2) The temperature of the WF-AFM1 [2] phase transition ($T_c \sim 27$ K) decreases by $dT_c/dP \approx -0.9$ K/kbar. (3) For the pressure P>10.5 kbar the intensive additional peak of susceptibility appears. It shifts to the low temperatures with the high velocity $dT_{max}/dP \approx -(5\div10)$ K/kbar. As a result at the (P, T)-phase diagram the triple point and an additional line appear which separate the weak ferromagnet phase region on the two regions: WF1 and WF2. On our opinion the high pressure (P>10,5 kbar) induces orientational phase transition in easy plane, which caused by a competition of magnetic crystallographyc and magnetoelastic anysotropy. One can sure detect this phase transition both in the monocrystal specimen and in thin powder. However, it is smeared out in the massive polycrystals due to an inhomogeneity of the internal stresses.

[1] Doroshev V.D., Krivoruchko V.N., Savosta M.M. et al.// JETP, 83(3), (1996), p.520.
[2] Stepanov A.A., Wyder P., Chattopadhyay T. et al.// Phys. Rev. B, 48, (1993), p.12979.

Fr-PB057

PHASE DIAGRAMS OF MISORIENTATION FERRITE GARNET FILMS

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Phase diagrams in inclined magnetic field and magnetoanisotropic character in misoriented epitaxial garnet films were received and investigated.
The case when normal-to-plane direction and external field are arbitrary in $(\bar{1}10)$-plane oriented is investigated. Phase diagrams form depends on film parameters. It was shown that the concrete correlation of magnetic anisotropy constants and the misorientation angle determinate an "inclined easy plane" state.
Such films can be used as high sensitive sensors of non-uniform magnetic fields.

Fr-PB058

THE ACCOUNT OF MAGNETOELASTIC AND MAGNETODIPOLE INTERACTIONS IN A TWO-DIMENSIONAL HEISENBERG FERROMAGNETIC

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We considered a two-dimensional Heisenberg ferromagnetic with magnetoelastic (ME) and magnetodipole interactions. Using the Hubbard's operators technique and bosonisation method we showed that in this model there exists a long-range magnetic order and investigated some of its unusual properties connected with the propagation of hybrydized ME waves in the system. With this purpose in mind we found the spectra of elementary excitations. The spectrum of low-frequency magnon branch has the ME gap and in the absence of ME interaction this spectrum coincides with Maleev's one. Obtaining the expression for the fluctuations of the magnetic moment, it is easy to show, that a long-range magnetic order in the system is stabilized and find the Curie temperature. From the quasiphonon spectrum we found, that there exist the forbidden regions for the wave vector $\vec{k} = (k\cos\varphi, k\sin\varphi)$ (with respect to φ) where the left (right)- polarized waves can not propagate.

Fr-PB059

THE INFLUENCE OF MAGNETOELASTIC INTERACTION ON THE FORMING OF THE ANGULAR PHASE IN A TWO-DIMENSIONAL HEISENBERG FERROMAGNETIC

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During last years the reorientation phase transition (RPT) in thin films Fe/Ag (100) or Fe/Cu (100) has been widely investigated. It has been shown that in such films the magnetization changes its direction with increasing of the temperature. We propose another mechanism of RPT like this, connected with the account of magnetoelastic (ME) interaction. First we suppose that the one-ion anisotropy has the form: $\zeta(T) = \beta(1 - T/T_0)$, where T is the temperature. When $T \ll T_0$, there is in system the phase with a magnetization axis, directed perpendicularly to the film and at $T > T_0$ magnetization is parallel to the plane. We showed that the account of ME interaction leads to the appearance of nonzero interval of temperatures $\Delta T \approx 10K$ where the angular phase is realized. We shall show that the RPT is the phase transition of the first order and find the temperatures of nonstability of the system. In addition to this we investigated the three-dimensional ferromagnetic and we have shown that in a 3D ferromagnetic with the account of ME interaction there is no angular phase and the temperature interval $\Delta T = 0$.

Fr-PB060

INVESTIGATION OF MAGNETOELASTIC CONTRIBUTION TO THE TEMPERATURE EXPANSION OF THE $Sm_2(Fe_{1-x}Si_x)_{17}$ CRYSTAL LATTICE

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Recently [1], it has been found that prolonged annealing of the $Sm_2(Fe_{1-x}Si_x)_{17}$ ($x \geq 0.015$) intermetallic compound with the rhombohedral *R(-3)M* structure (the Th_2Zn_{17} type) at T=1473 K leads to a spin reorientation of the magnetic moments from the (001) basal plane to the crystallographic *c* axis. Using the x-ray studies in the internal of 80-900 K a spin reorientation is show to be accompanied by a change in the lattice parameters and unit cell volume both at $T<T_c$ and at $T>T_c$. It is possible that this change is connected with small variations of the rhombohedral phase composition. The cause of lattice parameters change is discussed.
The magnetoelastic contribution to the temperature expansion of the crystal lattice is deduced from the X-ray studies. The contributions of exchange and linear magnetostrictions are separated.

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Fr-PB061

DYNAMICS OF DOMAIN WALLS IN THE FIELD OF AN ACOUSTIC WAVE PROPAGATE IN A PLANE OF DOMAIN WALL.

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In this communication we report on the theoretical investigation nonlinear dynamics 180-degree domain walls (DWs) in ferrimagnets in the elastic-stress field generated by an acoustic wave. Singularity of a problem is the propagation of a sound wave in plane of DW [1].

The direct influence of an arbitrary polarized running acoustic wave with arbitrary values of wave vector k on the DW is considered. The drift and vibration motion of solitary DW in magnetic with two non-equivalent magnetic sublattices is studied. It is shown, that $V_{dr} \sim (ku_0)^2$, where u_0 - the wave amplitude. The dependence of the drift velocity on the amplitude, polarization and frequency of the acoustic wave in ferrimagnets have been established.

The dominating contribution to the nonlinear dynamic DW is brought by transverse sound wave. At propagation of wave in plane DW the effect is stipulated by component of strain tensor perpendicular to plane DW. The analysis of a long-wave and short-wave approximation is carried out. The antiferromagnetic and ferromagnetic limits are explored. The conditions of the drift of a stripe domain structure in ferrimagnets are defined.

[1] Vlasko-Vlasov V.K., and Tikhomirov O.A. // Fiz. Tverd. Tela (Leningrad), 32, (1990), p.1678 [Sov. Phys. Solid State 32, 978 (1990)].

Fr-PB062

INFLUENCE OF MAGNETIC FIELD ON THE ELASTIC AND INELASTIC PROPERTIES OF THE TRANSITION METAL BASED AMORPHOUS ALLOYS

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The elastic and inelastic properties of the magnetostrictive amorphous alloys are strongly influenced by applied magnetic field. The numerical values of ΔE-effect and magnetomechanical attenuation strongly depends on the composition of the alloys (defining the values of the magnetostriction), the quantity of internal stress, type of the domain structure and on the orientation of domain magnetization vectors against the external magnetic field.

The results of elastic and inelastic properties examination in the transition metal based amorphous alloys with a strip and labyrinth domain structure in a frequency region of 10^2 - 10^6 Hz are represented in the present work.

It has been shown that the magnetomechanical hysteresis is a main mechanism of the mechanical oscillations damping at low frequencies while the eddy-current loss mechanism dominates in the high-frequency region. The large increasing of the ΔE-effect and magnetomechanical attenuation has been observed in the Fe-based alloys at heat treatment. The rising is due to reduction of the internal stress as a result of the structure relaxation.

Fr-PB063

INHOMOGENEITY OF NMR ENHANCEMENT FACTOR AND LOCAL MAGNETIC ANISOTROPY IN MAGNETICALLY ORDERED MATERIALS

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It is well known that the so-called inhomogeneity of the enhancement factor (η) of spin echo signal is an essential feature of NMR in magnetically ordered substances and the distribution function $F(\eta)$ is a potential source of a new information about the local magnetic anisotropy. In the given message we analyze the problem of the $F(\eta)$ reconstruction from the form and parameters of a spin echo signal. The results of the analysis of available literature data together with the theoretical accounts of one of the authors [1] lead to the following conclusions:

- the specified problem has the unequivocally defined algorithm of the solution (Fourier transformation) only in the case of the extremely narrow spectrum;
- attempts of $F(\eta)$ evaluation from more complex situations using the dependences of the amplitude of any echo signal vs. pulse duration are ambiguous because of the practical insensitivity of the considered parameters to the form of $F(\eta)$.

Two new approaches to the evaluation of $F(\eta)$ are proposed and their serviceability is demonstrated for some common magnetically ordered substances with extremely and moderately wide spectra.

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[1] Moskalev V.V. // Vestnik SPbGU, Fiz-Khim, (1999), issue 4, p.32 (in Russian).

Fr-PB064

PHASE DIAGRAM AND SPECTRA OF COUPLED MAGNETOELASTIC WAVES IN TWO-AXIS STRONGLY ANISOTROPIC FERROMAGNETS AT ARBITRARY ORIENTATION EXTERNAL MAGNETIC FIELD

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In the paper on the example of a two-axis ferromagnet there is demonstrated the role of large one-ionic anisotropy (OA) and magnetoelastic (ME) coupling in the originating of magnetic phases at arbitrary orientation of the external magnetic field at various temperatures. The application of the diagram technique for Hubbard's operators have enabled us to obtain the dependence of hybridized ME wave spectra on the value of OA. The boundary lines of magnetic phases with different types of ordering are found from the behaviour of ME wave spectra in the vicinity of phase transition lines.

It is demonstrated that depending on the orientation of the external magnetic field at large OA (much greater than the coupling interaction) there are possible both reorientational phase transition and the transition caused by the reduction of magnetization vector modulus. In the first case elastic and magnetic subsystem actively interact that causes the softening of a transversally polarized phonon mode in the point of orientational phase transition; in the second case these subsystem do not interact and the phase transition takes place with respect to magnon mode.

There is built the phase diagram of a strongly anisotropic two-axis ferromagnet at arbitrary orientation of the external magnetic field and arbitrary temperatures.

Fr-PB065
MAGNETICALLY DRIVEN SMA ACTUATOR

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In article some theoretical background and rough estimations propose to substantiate the physical and technical possibility for magnetically driven actuator based on shape memory alloys.
Magnetically induced transformations in ordering Fe_3Pt, Fe-Ni-Co-Ti and Ni_2MnGa are analysed. The reasons that are responsible for magnetically induced transformation in these shape memory alloys (SMA) are offered. Comparison with those ones responsible for perfect shape memory effect (SME) induced in ordinary ways is carried out. It is assumed that the high magnetisation per atom, low enthalpy of martensitic transformation (MT), high magnetic anisotropy and high mobility of the interface and intercrystalline boundaries are the necessary properties of material for the evidence of the shape memory effect driven by magnetic field.
The possible mechanisms of the SME driven by magnetic field are discussed. For the material undergoing MT as well as magnetic ordering transformation it could be the SME caused by the action of the pondermotive forces or the strain induced MT triggered by the magnetostrictive forces. Other way for the achieving magnetically driven SMA is to use the combined materials based on the ordinary SMA with the imbedded magnetic inclusions having high magnetostriction effect. A set of candidates that could be demonstrate SME induced by the magnetic fields technically easy achieved are proposed. They are classified depending on the type of the magnetic transformation associated with the martensitic one, heat of the MT transformation, dumping capacity associated with the MT and brittleness of the material.

Fr-PB066
SPIN–REORIENTATIONAL TRANSITIONS IN THE HEMATITE CRYSTALS DOPED WITH RARE EARTH IONS

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Owing to the strong influence of the rare earth ions on the magnetic anisotropy properties of the magneto–ordered crystals there are all reasons to expect the essential changes of the magnetic state in the hematite with the rare earth ions. Really, it was found by us that the α–Fe_2O_3: Ga (5at.%) crystals doped with dysprosium ions have spin–reorientational transition in the basal plane at $T \approx 15$ K. But the doping with terbium ions induces the transition "easy plane–easy axis" at $T \approx 170$ K which occurs through the angular magnetic phase as a second– order phase transition induced by magnetic field. Also, it was found that, with lowering temperature, the hematite crystals with samarium ions transfer from the easy axis state into easy plane one at $T \approx 135$ K. The transition occurs as a first–order phase transition. In the hematite crystals with terbium and samarium ions the increasing of the rare earth concentration leads to the increasing transition temperature. The rare earth concentration does not exceed 0.05 at.% in all cases.
The experimental results are explained in the framework of model when the host hematite crystal is described in the continual approach and the rare earth impurities is considered on the microscopic level taking into account the features of its individual electronic structure and interaction with the magnetic environment.

Fr-PB067

MEASUREMENT OF ANISOTROPY FIELD BY SECOND HARMONICS IN 3 % SILICON STEEL

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In this work, we measured the profile of second harmonics during *B-H* hysteresis loop as a function of the tensile stress. The [001] axis in (110)[001] grain oriented 3 % silicon iron of 120 mm(l) x 15 mm(w) x 0.3 mm(t), were prepared with the angle of 90^0 from rolling direction. The *B-H* hysteresis loops were measured by ballistic method, and the profiles of second harmonics were measured by lock-in amplifier using ac perturbing field of 1 kHz frequency, 80 Am^{-1} amplitude. The tensile stress was applied to sample axis. Fig. 1 shows the changes of hysteresis loop and second harmonics for (a) before and (b) after laser scribing in transverse direction. The inflection point of wasp-waisted *B-H* loop is disappeared and the field interval of second harmonics becomes broad by laser scribing. Fig. 2 shows the anisotropy field calculated by the field interval of second harmonics (a) before and (b) after laser scribing. In this paper, we will discuss the variation of anisotropy field of laser scribing sample in terms of the domain reorientation under the field and tensile stress.

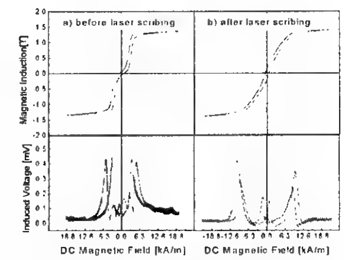

Fig. 1. Hysteresis loop and second harmonics (a) before and (b) after laser scribing

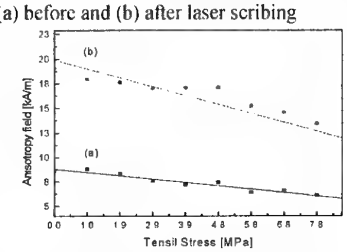

Fig. 2. The anisotropy field with tensile stress (a) before and (b) after laser scribing.

Fr-PB068

NEW EQUATION OF MAGNETIZATION MOTION

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Up to now there were well-known two frozen-in fields. The first one is the field of vorticity. The second frozen-in field is a magnetic field in a perfectly conducting fluid. Recently we put forward the general suggestion that the magnetization frozen in media of magnetic materials. The condition of frozen magnetization leads to new equation of magnetization motion.

$$\frac{d}{dt}\left(\frac{\vec{M}}{\rho}\right) = \left(\frac{\vec{M}}{\rho}\cdot\nabla\right)\vec{V}$$

We have developed the general theory of magnetoelasticity of solid insulator with the frozen magnetization. The set of equations that we have derived can be used to tackle many dynamical problems in magnetoelastic solids when the wave frequency far the magnetic resonance frequency. At present our theory was applied to describe the propagation of linear logitudinal and shear ultrasonic waves in solid insulator with the frozen magnetization. Using this theory we have explained the experimental results of magnetically induced ultrasonic velocity changes in polycrystalline nickel [1], and experimental results on the dependence of the logitudinal sound velocity of amorphous magnetostrictive ribbons and wires [2].

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Fr-PB069

PRESSURE EFFECT ON MAGNETIC SUSCEPTIBILITY OF $YbInAu_2$

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In accordance with the temperature dependence of the magnetic susceptibility $\chi(T)$ the $YbAuCu_2$ compound belongs to the Kondo system in the intermediate valence regime with characteristic temperature $T_K = C/\chi(0) \cong 700$ K (C is the Curie constant of the free Yb^{3+} ion). The pressure dependence of the magnetic susceptibility, $d\ln\chi/dP$, in $YbAuCu_2$ has been studied at some fixed temperatures in the range 20.4÷300 K. The estimate of the pressure derivative for the Kondo temperature, $d\ln T_K/dP = -38\pm2$ $Mbar^{-1}$, following from analysis of these data in the Coqblin-Schrieffer approach, appears to be consistent with the result of the pressure effect study of the resistivity. Supplemented by the temperature dependence of the bulk modulus these data can be examined within the Anderson model to elucidate the evolution of the main f-level parameters with the atomic volume change.

Fr-PB070

ODD PIEZOMAGNETIC EFFECT AND SOUND WAVES IN PIEZOMAGNETS

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Some singularities of the odd piezomagnetic effect (PME) as a kind of magnetic polarization of a medium with broken time reversal symmetry ($t \rightarrow -t$) are considered. As known PME exists in magnetically ordered phase of antiferromagnets with the center of symmetry for magnetic ions in sublattices. Symmetry properties of the elastic distortion tensor in that polarized state taken into account. Existence of antisymmetrical part of this tensor is essential for separation of transverse and longitudinal piezomagnetic polarization. For the first time both types of polarization in antiferromagnets were observed by Borovik-Romanov.
The structure of the own fields in sound wave in piezomagnetics is discussed. It is shown that inhomogeneous magnetic field in elastic wave is an elliptically polarized field. Then the vector of piezomagnetization rotates in a plane, where the wave vector q of elastic wave is lied. Here longitudinal component of piezomagnetic field has magnetostatic nature. It is essentially that not only transverse sound but also longitudinal sound can carry piezomagnetic moment.

Fr-PB071

ACOUSTIC BIREFRINGENCE IN ANTIFERROMAGNETS: NEW EFFECTS

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The acoustic birefringence (BF) in antiferromagnets (AF) having centersymmetrical (CS) or centerantisymmetrical (CAS) magnetic structures is discussed; a energy loss is disregarded. The existence of vector of antiferromagnetism **L** which is a order parameter leads to emergence of new mechanisms of BF and modification of the ones being at **L** = 0.

Considered are the following phenomena: 1) The plane Faradey's effect and the ellipticity in CS AF in state G [1] characteristic of orthoferrites, for instance, by sound transmission along **L** when the wave polarization rotates in the plane containing the wave vector **k**. 2) The circular BF in tetragonal CS AF of easy axes type (f.e. CoF_2) on conditions $\mathbf{L} \parallel \mathbf{k} \parallel 4_z$ and magnetic field **H** $\perp$ **k** (as a rule $\mathbf{H} \parallel \mathbf{k}$); in this case the rotational angle $\varphi \propto H^2$ (conventionally $\varphi \propto H$). 3) The linear BF in CS AF with the principal axes of symmetry 3_z (f.e. the hematite at the temperature below Morin's point) at geometry of experiment $\mathbf{k} \parallel \mathbf{L} \parallel 3_z \perp \mathbf{H}$: in this process the wave linear polarized at the input can acquire the arbitrary ellipcity at the output depending on magnitude and direction of **H**. 4) The nonreciprocal (that is depending on the sense of **k**) linear BF in CAS AF Cr_2O_3 ($\mathbf{L} \parallel 3_z \perp \mathbf{k}$) which is proportional L_z and $k_{x,y}$. 5) The circular BF in CAS AF having rhombohedral or tetragonal crystalochemical symmetry and being in the easy axes state in the presence of electrical field $\mathbf{E} \parallel \mathbf{k} \parallel \mathbf{L} \parallel 3_z$ (or 4_z).

It is likely that effects under consideration will be useful in solid state electronics.

[1]. Koehler W.C., Wollan E.O., and Wilkinson M.K. // Phys.Rev., 118,(1960),p.58.

Fr-PB072

ANISOTROPY OF THE MAGNETIC AND OPTICAL PROPERTIES OF RARE-EARTH ORTOALUMINATES $TbAlO_3$

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In this work made investigation of magnetic susceptibility, optical absorption and luminescention polarization spectra along of crystallographic directions [110] and [001]- axis "c" of rhombic crystal $TbAlO_3$ in interval of temperature 78-300K. The analysis of the experimental dates was made in accordance with suggestion of "Izing's" nature of magnetization of Tb^{3+} in orthoaluminate structure. It has shown that lower part of energy spectrum for ground multiplet $^7F_6$ contains two quasidublets (formed by near-located Stark singlets) are separated with energy interval ~ 200 cm^{-1}. The like Stark's splitting has also excited $^5D_4$ –multiplet of Tb^{3+}, that explains anisotropy of magnetic [1] and optical [2] properties of $TbAlO_3$.

[1] Valiev U.V., Lukina M.M., Saidov K.S. //Fiz.tv.tel.,41, (1999), p.2047.
[2] Sekita M., Miyazawa Y., Ishii M.//J.Appl.Phys.,83,(1998),p.7940.

Fr-PB073

CONFIGURATIONAL ANISOTROPY AND NON-HOMOGENEOUS EXCHANGE MODEL IN FERRO- AND FERRIMAGNETICS.

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The configurational anisotropy is studied by torque measurments for specimens with dimensions $l_1<l_2<l_3$ in magnetic fields $H>X_{pq}I_s$ (X_{pq} - the demagnetization factor function $X_{pq}=N_p-N_q$, $p\neq q=1,2,3$: I_s - the saturation magnetization). The maximum torque $P_m=1/2X_{pq}I_s^2V_f$ analyze as dependence on magnetic moment $L_s=I_sV_f$ (V_f - volume) under alternation of temperature (method PLT)
We suppose that the linearity of dependence PLT in the γ-phase of alloy Fe-31%Ni below Curie point indicate on local Curie point distribution (non-homogeneous exchange) and the first-order transition in correlation with magnetostriction results [1]. The linearity of PLT observed also in the alloys NiCo, CoMn, CoGd (ferrimagnetic) and in others.

1 Romanov A.U., Silin V.P. JETP (Russian), 113 (1998), p. 313

Fr-PB074

LOW TEMPERATURE EXPONENTIAL RELAXATION OF MAGNETIC STATES IN ANTIFERROMAGNETIC CRYSTALS

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The low temperature exponential relaxation of metastable magnetic states in bulk multisublattices antiferromagnet was observed by means of magnetostriction and rare-earth optical absorption spectra in Dy and Tb orthoaluminates. Two kinds of relaxation processes (fast and slow) were found. The slow process of relaxation resided in transformation of metastable antiferromagnetic structure A_xG_y (Γ_8) into the stable one A_yG_x (Γ_5) both formed due to the high anisotropy of Ising-like Dy^{3+} ions in $DyAlO_3$. The obtained temperature dependence of the escape rate Γ allowed one to find the energy barrier U~3.2 10^{-16} erg and estimate the number of magnetic ions which took participation in the unit act of mutual phase transformation by means of domain wall displacement (N ~ 10^1 - 10^2 ions). The Dy^{3+} absorption spectra show that the fast part of relaxation process is of the single ion nature.
This work was partly supported by RFBR (grant 98-02-16469) and Russian Ministry of Education (grant 97-0-7.3-157).

Fr-PB075

EFFECT OF PRESSURE AND Mn SUBSTITUTION FOR Fe ON MAGNETISATION, MAGNETOCRYSTALLINE ANISOTROPY AND SPIN-REORIENTATION TRANSITION OF Fe_3Ge SINGLE CRYSTAL

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The hexagonal DO_{19} phase ($P6_3/mmc$, $T_c = 623$ K) of Fe_3Ge which is stable at high temperatures (T>1000K) can be easily preserved at RT due to the slow formation kinetics of the $L1_0$ fcc structure. The Fe magnetic moment is 2.2 μ_B. The easy magnetisation direction is in the basal plane at low temperatures while a plane to axis spin reorientation transition (SRT) occurs at T_{sr} = 373 K. Since in DO_{19} phase there is a single crystallographic site for Fe (6h), the observed spin reorientation transition is not caused by a different temperature behaviour of competing contributions. In order to study the origin of the SRT and the magnetocrystalline anisotropy, single crystals of Fe_3Ge have been prepared by the chemical transport method. In addition, a polycrystalline sample with substitution of 20 % of Fe by Mn has been prepared. Mn substitution has been found to widely extend the axial region, shifting T_{sr} down to 126 K.
The effects of high pressure (up to 9 kbar) on magnetisation, magnetocrystalline anisotropy, and T_{sr} have been studied. High pressure reduces the magnetisation very slightly for both compounds. The anisotropy field (H_A) and thus the absolute value of anisotropy constant ($|K_1| = H_A M_s/2$) are both reduced by pressure in the planar region and T_{sr} decreases. Using the values of compressibility and of dT_{sr}/dP= -8K/Kbar, we can estimate that a decrease in volume of 1.2 % will completely suppress the planar anisotropy for the Mn substituted compound.

Fr-PB076

THERMAL EXPANSION AND MAGNETOELASTIC BEHAVIOUR IN Ni_2MnGa HEUSLER ALLOY

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The ferromagnetic Heusler alloy Ni_2MnGa undergoes a martensitic transformation at around T=215 K on cooling from the cubic $L2_1$ to a complex tetragonal structure. The coexistence of magnetic and structural degrees of freedom in the same alloy has attracted a great interest. Moreover, the possibility of inducing large strains under the application of relatively low magnetic fields has recently been reported [1]. Field induced strains of the order of 10^3 ppm have been found for saturating fields applied along specific crystallographic directions in single crystals.
For technical applications a systematic study of the magnetoelastic behaviour of polycrystalline samples is required. In this work we report thermal expansion and magnetostriction measurements up to 2 T and temperatures ranging from 10 K to 300 K on a Ni_2MnGa polycrystal. The magnetic-field-induced strain at the martensitic transformation strongly depends on whether the sample has been ZFC or FC. The maximum strain found has been of 3500 ppm.

[1] K.Ullakko, J. K. Huang, C. Kanter and R. C. O'Handley // Appl. Phys. Lett. 69 (1996) p.1966.

Fr-PB077
MAGNETOELASTICITY OF UPtAl

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UPtAl belongs to a wide group of uranium intermetallics U*T*X (*T* - a late transition metal, X - a p-metal), which crystallize in the ZrNiAl-type hexagonal structure. It is a ferromagnetic below T_C=43.5 K with a spontaneous magnetic moment $M_S \approx 1.4\mu_B$ per uranium [1]. In the present work, we have measured thermal expansion (TE) at ambient pressure and electrical resistivity (ER) at pressures up to 2.2 GPa on a single crystal grown by the Czochralski method in a tetra-arc furnace. The TE was measured by a strain gauge method. A standard dc four-probe method was applied for resistivity measurements. Hydrostatic pressure up to 2.2 GPa was generated by a piston-cylinder device.
Magnetic ordering in UPtAl is accompanied by pronounced anomalies in TE and ER. The TE is highly anisotropic both in the paramagnetic and ferromagnetic range. The room temperature TE coefficient along the *c* axis and in the basal plane reaches values of $0.45 \cdot 10^{-5}$ K^{-1} and $1.42 \cdot 10^{-5}$ K^{-1}, respectively. The linear spontaneous magnetostriction at T=4.2 K amounts $2 \cdot 10^{-4}$ and $-2 \cdot 10^{-4}$ parallel and perpendicular to the *c* axis, respectively, which yields a negative volume effect of $-2 \cdot 10^{-4}$. The negative spontaneous volume magnetostriction correlates with the positive value of $\partial T_c/\partial p \approx 2.0$ K/GPa, which demonstrates an enhancement of the exchange interaction with volume contraction. This behavior, which is rather unusual for *UTX* compounds with magnetism due to itinerant 5f states, indicates an incipient localization of 5f states in UPtAl.

[1] A.V. Andreev et al., J. Phys. Soc. Japan 68 (1999) 2426

Fr-PB078
REENTRANCE OF 5f-BAND METAMAGNETISM IN $U_{1-x}Y_xCoAl$ UNDER EXTERNAL PRESSURE

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UCoAl crystallises in the hexagonal ZrNiAl-type structure. It shows no indication of magnetic order, but in a magnetic field of 1T applied along the *c*-axis at T<16K a metamagnetic transition is observed to ferromagnetic state with U moments $M_U \approx 0.3\mu_B$ (the moment induced on Co atoms is one order of magnitude smaller). This behavior is attributed to the 5*f*-band metamagnetism. Unexpectedly, the $U_{1-x}Y_xCoAl$ solid solutions were found to exhibit ferromagnetism for x<0.15 [1]. The spontaneous magnetic moment first increases with x, reaches a maximum value of $0.22\mu_B$ for x=0.06 and then decays. T_C is nearly constant ($\approx$14 K) for x=0.02-0.08. The non-monotonous development of magnetism in $U_{1-x}Y_xCoAl$ is explained by a competition of two factors, the volume expansion and the non-magnetic dilution. In the present work, we have measured the magnetization on polycrystalline $U_{0.94}Y_{0.06}CoAl$ as a function of magnetic field and temperature in various pressures up to 1GPa using a SQUID magnetometer. We have observed very fast suppression of ferromagnetism with applied pressure; M_S vanishes already at 0.5GPa. Reentrance of the UCoAl-type band metamagnetism has been revealed as indicated by appearance of the typical S-shape of magnetization curve and of a broad maximum in the temperature dependence of magnetic susceptibility.

[1] A.V. Andreev et al., J. Magn. Magn. Mater. 196-197 (1999) 658

Fr-PB079

MAGNETOELASTIC ANISOTROPY DISTRIBUTION IN MAGNETOSTRICTIVE AMORPHOUS GLASS-COVERED WIRES

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The magnetic behavior of magnetostrictive amorphous glass-covered wires is determined by the magnetoelastic anisotropy that originates in the coupling between magnetostriction and internal stresses induced during preparation. In this paper we study the effect of the samples' dimensions – metallic core diameter, glass cover thickness, their ratio – on the magnetoelastic anisotropy distribution of such wires through the changes produced in their stress distribution. The results are important for the tailoring of the magnetic properties of such wires for sensor applications.
The radial distribution of internal stresses was calculated for samples with different dimensions in the as-cast state and for samples having the glass gradually removed. The results show that the shape of the curves that represent the radial distribution of axial, radial and circumferential stress components are qualitatively similar for all the investigated samples, although the stress values display wide variations. For wires with the core diameter of 4 μm, the maximum value of the axial stress component increases with the glass thickness from 1.25 GPa for a thickness of 4.5 μm to 1.72 GPa for 15 μm. The maximum axial stress decreases as the core diameter increases for wires with the same glass thickness, reaching from 1.25 GPa for the wire with the metallic core of 4 μm and the glass cover of 4.5 μm to 0.65 GPa for a wire with the same glass thickness but the core diameter of 20 μm. The quantitative changes of internal stresses are reflected by variations of the magnetic properties – coercivity, switching field, permeability, that in this way offer an experimental method for the validation of the calculated results.

Fr-PB080

EFFECT OF INSULATING COATING ON MAGNETIC ANISOTROPY OF ORIENTED ELECTRICAL STEELS

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The insulating coatings of oriented electrical steels generates the elastic stresses because of differense of the thermal expansion coefficients for metal and coatings. These stresses affects on magnetic properties of electrical steel and may decrease the magnetic losses to 3-9% rolling direction. More significant effect is for stress sensitive characteristics at angles to rolling directions. Thus in direction transvers to rolling under influense of coating the coercivity increase on 80-200% and low magnetic induction decrease on 50-100% . These values depends from adhesion and thickness of coatings and from intensity of crystallografic texture of steel.
The values of magnetic anisotropy of stress sensitive properties may be use for estimating magnetic activity and quality of the insulating coating.

Fr-PB081

DISPERSION OF SOUND VELOCITY IN IRON BORATE UNDER THE NUCLEAR MAGNETIC ACCOUSTIC RESONANCE CONDITIONS

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The present paper is devoted to the investigation of sound velocity dispersion in weak ferromagnetic $FeBO_3$.

The acoustic measurements, namely the measurement of relative velocity, where the sound velocity away from the resonance of constant magnetic field H^*=60 Oe and at frequency of acoustic oscillations being excited were performed by the phase-pulse procedure [1].

In the present work the dependence of relative variation of phase velocity $\Delta\upsilon/\upsilon_s$ on the frequency of ultrasound oscillations has been obtained. As we approach to the NMR frequency from the lower frequencies the decrease of phase velocity occurs and when from the higher frequency - the increase. Maximum variation of phase velocity at monodomain state of $FeBO_3$ sample accounted for ~20% with the change of sign of dispersion at $\omega=\omega_n\approx 75{,}4$MHz. The error of measurements of $\Delta\upsilon/\upsilon_{s0}$ magnitude accounted for $\sim 10^{-2}$.

The run of the dependence curve of sound velocity in the sample in itself is defined by the contribution of effective modulus of elasticity of specially varied part of nuclear magnetization via the hyperfine and ME coupling.

[1] V.R. Gakel. JETF **67**, *5(11)*, 1827 (1974).

Fr-PB082

NMR OF ^{57}Fe NUCLEI IN $BaFe_{12}O_{19}$ DOMAIN WALLS WITH SMALL ANISOTROPY OF LOCAL FIELDS

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Features of stationary NMR spectra of ^{57}Fe nuclei at 2b and $4f_2$ crystallographic localizations of Fe^{3+} ions at hexaferrite $BaFe_{12}O_{19}$ domain walls (DW) have been investigated. The coincidence of NMR local frequencies in center - ν_w and at edge - ν_d of DW at 260K has been observed experimentally. The result is the significant growth of the intensity of NMR signals. It is shown that equality of ν_w and ν_d is due to compensation of different contributions to the anisotropy of local frequencies. These contributions occur because of anisotropy of superfine and dipole fields and also as a results of the local magnetization decrease in DW center in comparison with DW edge owing to thermal exciting of inner boundary magnons.

Fr-PB083

COMPUTER MODELS IN RESEARCHES OF AN ANISOTROPY OF A MAGNETIZATION AND PHASE TRANSITIONS

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The principles of model computer experiment are developed to research of equilibrium condition of a magnetization of magnetic-ordering chips. The basis make is formed with:

- the analysis of an anisotropic part of a thermodynamic Gibbs potential in the space of K_1, K_2 and K_3 decomposition factors according to order parameter;
- tracing of the anisotropy orientation phase diagrams;
- numerical solution of an condition equation for chips structural classes;
- definition of the magnetization and magnetic field critical values in the field of spin-reorientation phase transitions and their dynamics.

The outcomes reliability and efficiency of model computer experiment are confirmed with it compliance with known experimental data, available in the literature source, in rare-earth orthoferrites and garnet, cobalt and cobalt-containing hexaferrites, neodymium-iron-aluminium alloys, high-anisotropic dusts of nanometre degree of dispersion and other ferromagnetics.

The developed physical principles of model computer experiment and it outcomes can be used to forecaste and to research different physical properties of chips (magnetic, electrical, thermal, mechanical, etc.) of any structural class, if these properties are described by symmetrical tensors or tensor series. They can be used to design superdense-record information systems, survivable aircraft and so on.

Fr-PB084

THE MODEL AND OBSERVATION OF GIANT MAGNETO-MECHANICAL EFFECTS IN MARTENSITIC STATE OF Ni_2MnGa.

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Some ferromagnetic shape memory alloys were recently suggested as a general way for the development of a new class of the magnetic-field-controlled actuator materials that will allow control of large strain effect by application of a magnetic field. Up to date, the largest magnetostrain effects were observed in Ni_2MnGa Heusler alloy. It is generally believed that a large macroscopic mechanical strain induced by the magnetic field is realized trough the twin boundaries motion and redistribution of different twin variant fractions in a magnetic field. Recently, several research groups have reported on the observation of super large magnetostrain effect in some non-stoichiometric Ni_2MnGa alloys comparable with a tetragonal 5% crystal lattice distortion of martensitic phase. A quantitative model describing large magnetostrain effect observed in several ferromagnetic shape memory alloys such as Ni_2MnGa recently developed by authors and successfully applied to explain the results of experimental study of large magnetostrain effects in Ni_2MnGa earlier obtained. The main goal of this report is to represent the quantitative model describing large magnetostrain effect and main mechanical and magnetic properties observed in several ferroelastic shape memory alloys such as Ni_2MnGa and discuss its application to giant magnetostrain materials.

Fr-PB085

EFFECTS OF CRYSTAL FIELD AND QUADRUPOLE INTERACTIONS IN $YBVO_4$ AND $YBPO_4$

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The magnetic and magnetoelastic properties of $YbPO_4$ and $YbVO_4$ which have the zircon-type tetragonal structure are analyzed within the extended susceptibility and crystal field formalisms on the basis of the magnetization and magnetostriction measurements in fields up to 7.6 T in the temperature range 1.5-200 K. The magnetoelastic coefficients and quadrupolar constants for all the symmetry lowering modes are determined from the data for the temperature dependences of the third-order magnetic susceptibility and elastic constants and the temperature and field dependences of magnetostriction. Their coherency within the different experimental techniques and within the series of rare earth zircons is emphasized. For both Yb zircons the dominant magnetoelastic coupling is associated with the γ symmetry, it is responsible for the positive third-order magnetic susceptibility along [100] axis and an essential softening of the elastic constant C^{γ}. The nonmonotonous temperature dependence as well as the change of magnetostriction sign for various symmetry modes due to crystal field effects are observed. Magnetoelastic effects and magnetoelastic couplings have been compared for two Yb compounds. The possibility of the stimulated quadrupole ordering at high magnetic fields is also discussed.

Fr-PB086

FINE STRUCTURE OF ACOUSTIC COTTON-MOUTON EFFECT IN IRON BORATE

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The dependence of amplitude of transverse sound passed through a basal plate of easy-plane weak ferromagnet $FeBO_3$ on magnetic field H parallel to the plate is investigated in experiment at T=77K. This dependence is associated with magnetic additions to elastic modules for one of two linearly polarized modes of transverse sound [1]. The curve of the effect has a fine structure, which is a small-period oscillations of amplitude. Model talking into account experimental boundary conditions and block structure of the real $FeBO_3$ crystal is constructed. Calculations based on the model describes the experimental fine structure satisfactory.

[1] Turov E.A.// Zh. Eksp. Teor. Fiz., 96, (1989), p.2140 [Sov. Phys. JETP 69, (1989), p.1211].

Fr-PB087

PROPAGATION OF ELASTIC TRANSVERSE WAVES THROUGH MAGNETIC LAYER SEPARATING TWO ELASTIC HALF-SPACES

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The influence of magnetoelastic interactions on the propagation of transverse elastic waves through a ferromagnetic layer separating two elastic nonmagnetic half-spaces is investigated. Consideration is given to a wide frequency range of elastic waves, which includes frequencies near the magnetoacoustic resonance of a ferromagnetic plate. By solving a boundary-value problem, it is shown thet near the magnetoacoustic resonance frequency, the transmission and reflection coefficients of elastic waves in this layered structure can vary with the magnetic field and the thickness of the ferromagnetic layer anywhere from 0 to 1 on neglecting wave attenuation.
A solution is obtained to the boundary-value problem arising when transverse elastic waves propagate across an antiferromagnetic layer separating two elastic half-spaces under the linear approximation of magnetoelastic coupling. It is shown that, subject to certain constraints imposed on the layer thickness and wave frequency, an elastic wave can be totally reflected from the antiferromagnetic layer. The propagation of elastic waves across interfaces near orientational phase transition in the antiferromagnetic layer is examined in detail.

Fr-PB089

MAGNETIC PHASES IN Gd-Y ALLOYS: ORDER PARAMETERS AND CRYSTAL LATTICE

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The transformations of magnetic and lattice subsystems states of $Gd_{100-x}Y_x$ (x=0, 5.5, 7.5, 10.2) alloys have been studied at temperatures 5-370 K in magnetic fields up to 4 kOe. There were investigated the temperature dependences of elastic modules, thermal expansion, magnetic susceptibility, and magnetic anisotropy parameters. Four magnetic phase transitions were revealed in alloys (instead of two in pure Gd), and their types were suggested. It was found, that the description of observed temperature behavior of magnetic and lattice systems requires to take into account an exchange interaction of different sign in the 1st and the 2nd coordination spheres, as well as no less than two magnetic anisotropy parameters. These different forces (as well as chaos in the spatial distribution of magnetic ions) cause different order parameters and a coupling between them. Strong effect of atomic disorder on magnetic structure is caused by substantial role of 5d electrons in the forming of magnetic states in rare earth metals. The following magnetic phase diagram of the system is suggested (a magnetic structure is indicated and a transition order while it changing): paramagnetic – (II order) – ferromagnetic cone – (I order) – ferromagnetic helix – (pare II order transition) – (a) deforming ferromagnetic helix – (b) canted ferromagnetic.

Fr-PB089

RELAXATION MECHANISMS OF MAGNETIZATION IN DILUTED HEISENBERG SYSTEM $Li_{0.5}Fe_{2.5-x}Ga_xO_4$

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Results of a study of the thermoactivated relaxations of magnetization in the diluted ferrimagnetic spinels $Li_{0.5}Fe_{2.5-x}Ga_xO_4$ with x=0.8; 0.9 and 1.4 are presented. These concentrations correspond to the reentrant region of x-T phase diagram. It is established that in cases of a static experiment the observed relaxation processes are determined by the three mechanisms:
i) the transition into ferrimagnetic spin glass state; ii) the presence of domain boundaries; iii) the presence of the ferrimagnetic structure inhomogeneities in the form of cluster which due to magnetic field and temperature make a transition into a superparamagnetic state. In the most cases the relaxation of magnetization correspond to a wide spectrum of activation energies and it is described by a logarithmic law ($\Delta\sigma \sim S\ln t$), but each of the above listed mechanisms manifests as a specific feature of the viscosity coefficient S=S(x,T,H) behavior. For the sample with x=1.4 it is found that at different quantities of field H and temperature T logarithmic law or exponential one ($\Delta\sigma \sim e^{-t/\tau}$) may take place.

Fr-PB090

FIELD INDUCED MAGNETIC PHASE TRANSITIONS IN EXTREMELY ANISOTROPIC MATERIALS

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Magnetic phase transitions induced by a high magnetic field at low temperatures in $Dy_xY_{3-x}Fe_5O_{12}$ single crystals (x=0.3; 0.62) are studied experimentally and theoretically. The magnetization and differential magnetic susceptibility curves have been measured at T=4.2-200K in pulsed magnetic fields up to 50 T, oriented along the [100], [110] and [111] axes. Magnetic reversal of the rare-earth magnetic subsystem is revealed by sets of several phase transitions in the 5-40 T range, depending on x, T and the direction of the external field. These results demonstrate that this compound belongs to the group of Ising magnets with extremely large magnetic anisotropy. A good quantitative description of the magnetic properties of the crystals is obtained in the framework of a model of the quasi Ising ordering of Dy^{3+} ions. The model is based on the assumption that the local axes of anisotropy are oriented along directions of the type [110] and the g-factor of Dy^{3+} ions has more than one non-zero components. Experimental and numerically calculated magnetic phase diagrams of $Dy_xY_{3-x}Fe_5O_{12}$ on the “H-x” and “H-T” planes are compared. All theoretically predicted sets of field induced magnetic phase transitions were obtained in the experiments, proving adequacy of the model.

Fr-PB091
DYNAMIC MAGNETIC BEHAVIOR OF GLASS-COATED MICROWIRES

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Complex permeability of glass coated microwires was experimentally studied in the 0.1 - 30 MHz frequency range. The previous investigation indicates that the microwire is a strongly anisotropic material characterized by uniform magnetization due to coherent moments rotation [1]. For this case, the complex permeability of the wire is described by the well known equation:

$$\tilde{\mu} = \mu_i \cdot \frac{J_1(\gamma \cdot r)}{J_0(\gamma \cdot r)} \cdot \frac{2}{\gamma \cdot r}; \qquad (1)$$

where γ is the wave vector in the conducting material, and r is the wire radius.
The experimental results obtained by us demonstrate a considerable disagreement with the equation (1). We analyzed the possible causes of difference in the permeability values obtained experimentally and those predicted by the equation (1). An improved model for the dynamic behavior of microwires is proposed, still assuming the coherent moments rotation.

[1] A. N. Antonenko, E. Sorkine, A. Rubshtein, V. S. Larin, V. Manov, J. Appl. Phys. V.83, No. 11, p. 6587, 1998.

Fr-PB092
INVESTIGATION OF MAGNETIZATION PROCESSES IN FERRITES WITH COMPENSATION TEMPERATURE BY MEANS OF MAGNETOSTRICTION MEASUREMENTS

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The behaviour of parallel $\lambda_{\|}$ and perpendicular $\lambda_{\perp}$ magnetostrictions of ferrite $NiFeCrO_4$ (Compensation temperature T_c=325 K, Curie temperature T_C=575 K) have been studied for the first time. It was found that the Akulov rule for the magnetostrictions $\lambda_{\|} = -2\lambda_{\perp}$ for nonfrustrated magnetic structure takes place above T_c, whereas this correlation is not justify below T_c.
Earlier we concluded [1], that anomalous magnetization curve $\sigma_s(T)$ N-, P- and L-type are connected with the presence of a frustrated magnetic structure in the only one of sublattices of ferrite spinels. From the temperature dependences $\lambda_{\|}(T)$ and $\lambda_{\perp}(T)$ for $NiFeCrO_4$ we supposed that the frustrated magnetic structure exists only in B-sublattice, which is responsible for magnetic moment of ferrite below T_c, at the same time the magnetic structure is nonfrustrated in A-sublattice, which is responsible for magnetic moment of ferrite above T_c.
This conclusion is in agreement with results of Ref. [2] where it was shown from the Mössbauer measurement that at the room temperature the ferrite $NiFeCrO_4$ is a «frustrated ferrimagnet» where the ferrimagnetically ordered and frustrated spins coexist.

[1] L.G.Antoshina, A.N.Goryaga, V.V.Sankov // Fizika Tverd. Tela, to be published.
[2] J.K.Srivastava, G.Jehanno // J.Phys.Soc.Japan, 56, (1987) p.1252.

Fr-PB093

INFLUENCE OF Ni^{2+} IONS WITH GENERAL ORBITAL TRIPLET STATE ON MAGNETIC PROPERTIES OF FERRITE $NiFe_{0.5}Cr_{1.5}O_4$

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For the first time the behaviour of magnetization σ, parallel $\lambda_{||}$ and perpendicular $\lambda_{\perp}$ magnetostrictions of ferrite $Ni^{2+}{}_{0.5}Fe^{3+}{}_{0.5}[Ni^{2+}{}_{0.5}Cr^{3+}{}_{1.5}]O^{2-}{}_4$ in which the general state of Ni^{2+} ions is orbital triplet in tetrahedral sites was investigated at temperature 4.2 in a field up to 55 kOe.
It was found that the saturation is absent at the isotherms $\sigma(H)$, $\lambda_{||}(H)$ and $\lambda_{\perp}(H)$, but the coercive force H_c, parallel $\lambda_{||}$, perpendicular $\lambda_{\perp}$, volume ω and anisotropic λ_t magnetostrictions have the anomalous great values. For example, $H_c \approx 12$ kOe and $\omega \approx 820 \cdot 10^{-6}$ and $\lambda_t \approx -1800 \cdot 10^{-6}$ in the field H = 55 kOe.
We conclude that the large value of ω results from presence of large paraprocess in this ferrite, moreover the susceptibility of magnetostriction has an anisotropic nature: $\Delta\lambda_{||} < 0$ and $\Delta\lambda_{\perp} > 0$. However paraprocess is much smaller and susceptibility $\Delta\lambda_{||} < 0$ and $\Delta\lambda_{\perp} > 0$ have isotropic character for the nickel ferrites-chromites $Fe[NiFe_{1-x}Cr_x]O_4$ ($x \leq 1.0$) studied by us earlier, in which Ni^{2+} ions are absent in tetragedral sites unlike ferrite $NiFe_{0.5}Cr_{1.5}O_4$.
We supposed that such anomalous behaviour of $\lambda_{||}$ and $\lambda_{\perp}$ magnetostrictions arise from the spin-orbital interaction of Ni^{2+} ions in tetrahedral sites of spinel lattice.

Fr-PB094

ALTERNATING MAGNETIZATION PECULIARITIES OF THE (111)-FILMS WITH HIGH DENSITY OF DEFECTS

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The influence of magnetic defects on equilibrium distribution of the domain structure and on domain borders dynamic was studied in this work. For these purposes the ferrogarnetic films of type (111) with high density of defects (~10^6 cm^{-2}) were synthesized [1]. In this case an influence of defects on the domain structure and its dynamic is determining what follows, for example, from fractal configuration of the equilibrium domain structure and specifics of its reorganization in the magnetic field. We studied experimentally the geometry of the domain structure, static B-H curve and hysteresis loop, and also the fractal dimension of the domain structure and its borders. According to experimental researches, the process of formation of a new magnetic phase from homogenic condition passes as a growth of fractal clusters with embryos of reverse magnetization in centers.
The results of computer design are being compared with the experiment. It was found that the fractal dimension of the domain formations, the shape of B-H curve and hysteresis loop very much depend on functions of distribution of defects in the plane of the film and on the structure of a separate defect. The results of design are most similar to the results of experiments, if the defects distributed in the plane of the film according to the normal rule and a field of a separate defect is close to the normal distribution (the Gauss's distribution).

[1] Dovbnya L.A., Khramov B.V. Reports thesis's of the International Conference of young scientists "Optic-99", St-Petersburg, 1999, p. 16-17.

Fr-PB095

THE INFLUENCE OF POINT DEFECTS ON THE PROCESSES OF MAGNETIZATION IN FERROMAGNETS.

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It is well known that the domain wall (DW) motion in external magnetic field is performed as transitions between different metastable states of the DW. [1] We discuss the behaviour of the DW of the thin ferromagnetic film with randomly distributed point defects in external magnetic field, which changes by the time. At sufficiently high velocities of change it is possible to neglect of the influence of the thermally activated jumps between the different metastable states. With assumption that the interaction between the DW and the defects is rather small we consider the change of the DW as a small disturbance. In the common case equations for distribution function of the DW on the multitude of metastable states forme the BBGKY endless chain of equations . On the other hand, in accordance with the principle of spacial weakening of correlations, the mutual influence of different DW fragments decreases with increase of distance between them. Thus, considering the isolated DW fragment, we write the master equations for the DW motion in assumption, that the DW pins at no more than two defects. It makes possible to find the expression for the coercivity and magnetic susceptibility of the thin ferromagnetic film with randomly distributed point defects.

[1] G. Bertotti, I. D. Mayergoyz, V. Basso, and A. Magni.// Phys. Rev. E, 60, (1999), p. 1428.

Fr-PB096

MAGNETIZATION PROCESSES OF TETRAGONAL ANTIFERROMAGNET

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The domain structure may greatly affect many physical properties of antiferromagnets. First of all, influence of domain structure can reveal itself in processes of magnetization. In multiple-axis antiferromagnets, the influence of the domain structure upon magnetization processes can manifest itself even in sufficiently weak fields [1]. With magnetization being aligned along one of the antiferromagnetism axes, as shown in, a substantive contribution can be made by the shifting processes of 90-degree domain walls.

In this paper a theory of the 90- and 180-degree domain structure in an easy-plane tetragonal antiferromagnet with inhomogeneous internal magnetostrictive and mechanical stresses has been developed. Dependencies of critical fields of stability loss of the 90- and 180-degree domain structures upon a directional external pressure, and magnetostrictive and inhomogeneous mechanical stresses have been determined. The dependence of the magnetization curve on mechanical stresses has been determined too. The results of micromagnetic description of the domain structure reconstruction processes in magnetic fields prove the validity of the principal statement put forward in [1] when phenomenological describing magnetization curves of the $FeGe_2$ antiferromagnet.

[1] Vlasov K.B., Zainullina R.I., Milyaev M.A. and Ustinov V.V. // JMMM, 146, (1995), p.305.

Fr-PB097

MAGNETIC AFTEREFFECT AND HYSTERESIS IN THIN FILMS

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It is well known that domain wall (DW) motion in response to a slowly change in external magnetic field is performed by means thermal activated jump between different metastable states of DW, which arose from DW interaction with defects. In this work domain wall motion in ferromagnet with randomly distributed point defects is considered in small density limit. DW sate is characterized by coordinates of defects which pin DW. Equation for probability of pinning DW by each defect is obtained, taking into account thermal fluctuations of magnetization. On this base, coercive field and hysteresis loop dependence on the value and frequency of an external magnetic field is found and magnetic viscosity and disaccommodation phenomena are explained for this case.

[1] Zapperi S., Cizeau P., Durin G., Stanley E.// Phys. Rev. B, 58, (1998), p. 6353

Fr-PB098

THERMAL REMAGNETIZATION OF PERMANENT MAGNETS - INFLUENCE OF MAGNETOSTATIC INTERACTION, STARTING TEMPERATURE AND AFTER EFFECT

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The thermal remagnetization (TR) of permanent magnets, i.e. the irreversible increase of the magnetization due to temperature increase after dc-demagnetization at the starting temperature T_0, is strongly correlated with the temperature coefficient of the coercivity and with the coercivity mechanism.
In the paper experimental results are given about the influence of T_0, the demagnetization factor and small external fields on the TR at different kinds of $SmCo_5$ and other permanent magnets of different demagnetization factors N. Time dependend magnetization changes of both signs has to be considered.
It has been shown, that the large measured effects on $SmCo_5$ may be interpreted by a selfconsistent theory, which takes into account an ensemble of ideal-aligned grains with square-shaped hysteresis loops. The switching fields are gaussian distributed and assumed to decrease linearly with temperature. Furthermore a distribution of the local magnetic fields is taken into account with a distribution width itself being dependent on the magnetization.

Fr-PB099

TWO ASSUMPTIONS BEING USED FOR GETTING AN ADEQUATE MATHEMATICAL DESCRIPTION OF THE DYNAMIC HYSTERESIS LOOPS

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The process of magnetization reversal of soft magnetic materials is known to be complicated in details. Nevertheless a very good mathematical description of families of dynamic hysteresis loops is possible in the case of the acknowledgement of two assumptions as true. One of them concerns the complicated influence of the domain structure on eddy currents. It may be taken into consideration by means of replacing in classical eddy current equations the actual electrical conductivity of the material by the «equivalent» electrical conductivity, which depends on the parameter of domain structure. This is confirmed by the comparison of dynamic hysteresis loops, calculated on the classical condition of the homogeneous magnetization and with taking into consideration of domain wall moving. The second assumption concerns the manner in which magnetic viscosity with a small relaxation time is described mathematically. We suppose that this phenomenon obeys an equation which is a new modification [1] of the known equation of magnetic viscosity. As a result we could realize in the case of the week magnetic skin effect the opportunity of getting a simple equation of the dynamic magnetization reversal. The equation corresponds in a surprising way to experimental dynamic hysteresis loops on the different conditions of the magnetization reversal.

[1] Kadochnikov A.I. A modified equation of magnetic viscosity .The Physics of Metals and Metallography, Vol. 83, No.2, 1997, pp. 165-172.

Fr-PB100

DIFFRACTION OF LIGHT ON DYNAMIC ELASTIC DEFORMATIONS OF DOMAIN WALL IN ORTHOFERRITES AT TRANSITION THROUGH SOUND BARRIER

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For rare earth orthoferrites the padding magnetic ordering in a sublattice rare-earth R^{3+} is characteristic. In these conditions it is necessary to expect strengthening of interactions magnon and phonon subsystems when velocities of motion of a wall to coinside with acoustic velocities and specially at the moment of overcoming by her of a sound barrier. The researches of dynamics domain wall in $TmFeO_3$ and $DyFeO_3$ (at temperatures 168K and room) method of a twofold microphotograph of double dynamic domain structure in real time have allowed to find out a phenomenon of diffraction of a pulse laser radiation on elastic dynamically induced deformations separable from them at the moment of overcoming of a sound barrier. On microphotographs of double dynamic domain structure she represented interleaved light and dark bands. Under the data of microphotometric measurements the distribution of light intensity between separate light bands optimally corresponded to a diffraction of light on a phase grating. It is possible, that in this moment the wall is strongly tilted, that even more promotes pumping induced elastic dynamically deformations. In the supposition, that the period of grate coincides with wavelength of sound oscillations, the value of their wave vector was counted, which one has appeared equal 1×10^5 cm^{-1}. On same basis the frequency excited elastic vibrations – 10 GHz is also determined. The opportunity of observation this phenomenon was caused by application in our case of pulses of light with duration less than 1 ns. It's time corresponds high bound of a life time of exciting phonon oscillations probably. In previous experiment's the diffraction of light on acoustic waves resonance excited domain wall was not detected, in accordance with that more pulse length of light was used.

Fr-PB101

MODELING THE IRREVERSIBLE MOTION OF THE DOMAIN WALL

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The equation of the domain wall (DW) motion has been studied by the numerical Kutta-Merson method

$$m_{eff}\ddot{x}(t) + \beta\dot{x}(t) + F(x) = 2M_s H(t)\cos\alpha \quad , \qquad (1)$$

where m_{eff} is the effective mass per unit surface area of the DW; β is the damping coefficient; $F(x)$ is the function with which the potential-relief gradient is fitted; M_s is the saturation magnetization; $H(t)$ is the magnetization reversal field; and α is the angle between the directions of M_s and $H(t)$. The condition which provokes oscillating motion in solution (1) has been found out. It is displayed in computer numerical experiment. The conditions which lead to getting and registering oscillating motion in a physical experiment have been defined.

Fr-PB102

MAXWELL VELOCITY DISTRIBUTION OF MOBIL SEGMENTS OF LABYRINTH DOMAINS IN LOW-FREQUENCY MAGNETIC FIELD

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For theoretical descriptions of domain structure transformation processes in variable fields, the concept of effective temperature defined through mean kinetic energy of domains or domain walls is used [1,2]. Using of temperature concept requires the proof of chaotization of domain or domain wall motion in a uniform variable field.

In the present work the experimental investigation of velocity distribution of movable domain segments at quasistatic magnetization reversal of labyrinth domain structure (LDS) was performed. Uniaxial films of substituted ferrite garnet were used. The acoustic oscillations of domain segments in a low-frequency field were studied through examining images of LDS. The velocity distributions of movable segments localized on bends of strip domains were obtained. The distributions were found to be unsymmetrical nonmonotone dependences. The compliance of experimental dependence to the calculated Maxwell distribution for two-dimensional particle system was obtained. The results indicate that it is possible to apply the concept of temperature for the description of bent strip domain segment oscillations. The possible mechanism of chaotization of their motion can be related to the interaction of movable segments with inhomogeneities of LDS and each other.

[1] Zablotskii V.A., Mamalui Yu. A. // J.Phys.: Condens. Matter 7, (1995), p. 5271.
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Fr-PB103

STRONG FIELD SWEEP RATE DEPENDENCE OF THE MAGNETIZATION PROCESS IN HIGHLY ANISOTROPIC ANTIFERROMAGNETS $ErGa_2$ and Dy_3Co

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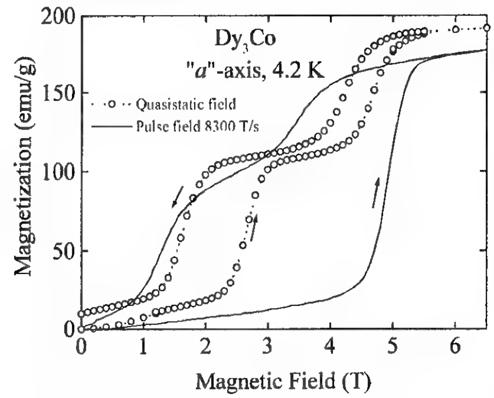

The magnetization curves along the main crystallo-graphic directions of single crystalline $ErGa_2$ and Dy_3Co samples have been measured in both quasistatic and pulsed magnetic fields. Both compounds are antiferromagnets with a strong magnetocrystalline anisotropy and exhibit metamagnetic transitions to the field-induced ferromagnetic state. In quasistatic field, a two-steps-like metamagnetic transition through an intermediate ferrimagnetic phase was observed along "*c*" axis of $ErGa_2$ and along "*a*" axis of Dy_3Co. Alternatively, in pulse fields the metamagnetic transition in both compounds occurs as a single step and is accompanied by heating of the samples. Owing to the quasiadiabatic pulse field magnetization process the temperature growth may exceed 20 K. The shape of the magnetization curves in pulse fields was found to depend strongly on the field sweep rate and on the initial temperature of the sample. The obtained results have been discussed in terms of the thermally activated nucleation of the ferromagnetic phase and the displacement of the interphase boundaries.

Fr-PB104

PERMINVAR EFFECT IN AMORPHOUS FeCrSiB ALLOYS

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The Perminvar effect in amorphous $Fe_{80-x}Cr_xSi_6B_{14}$ (x = 0-14 at.%) alloys was investigated.
The field dependence of the susceptibility of the investigated alloys doesn't obey the Rayleigh law χ =a+bH, but χ=const up to the critical field (H_{cr}). This effect is connected with the reversible movement of the domain walls (DW). At the higher amplitude of the magnetic field ($H>H_{cr}$), the irreversible movements of the DW lead to the rapid increase of the susceptibility [1,2]. Since $\chi^{-1}\sim d^2E_s/dx^2$, the Perminvar effect gives an experimental evidence about the parabolic shape of the DW potential. The Perminvar effect is a result of the magnetic relaxation and therefore, H_{cr} depends on the time and the temperature of of the demagnetized state stabilization.
The Cr addition decreases the critical field H_{cr} at which the susceptibility increases as a result of the irreversible movement of the domain walls.
The obtained results are compared to the magnetic after-effect (MAE) investigations [3] which show the non-monotonous decrease of the MAE peak as a function of Cr content.

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[3] Varga R., Vojtanik P. // J.Magn.Magn.Mater., 196-197, (1999), 230.

Fr-PB105

INVESTIGATION OF μ^* - EFFECT NEAR THE GRAIN BOUNDARIES IN GRAIN – ORIENTED SILICON STEEL SHEETS.

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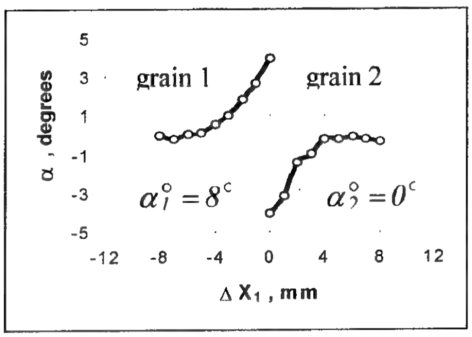
Some regularities of magnetization $\vec{M}(\vec{r})$ distribution and behavior of domains near the planar grain boundaries (GB) in grain – oriented silicon steel sheets, which had been magnetized to the saturation ($M = M_S = 1.59 \cdot 10^6$ A/m) by homogeneous external magnetic fields $\vec{H}^e$, were investigated. It was found that there are such perturbations $\delta\vec{M}_S$ of the net magnetization, which is the direct experimental evidence of the μ^* - effect [1] existence (the deviation $\Delta\alpha$ of vectors $\vec{M}_s$ from easy direction <100>) at the GB. The peculiarities of this effect (fig.) near the planar GB ($\Delta x_1 = 0$ is the planar GB) with different orientation of axes <100> (α_1° and α_2°) at neighboring crystals of investigated sheets are discussed. The thermodynamics proof of μ^* - effect at GB was obtained within the frame of the theory of scalar magnetic potential.



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Fr-PB106

INVESTIGATIONS OF MAGNETOSTATIC STRAY FIELD $\vec{H}^m$ ENERGY f_S NEAR THE GRAIN BOUNDARIES IN GRAIN-ORIENTED SILICON STEEL SHEETS.

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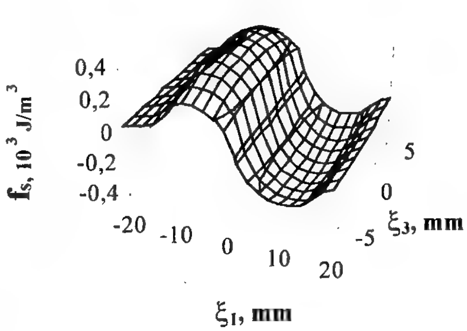
Inhomogeneity of net magnetization $\vec{M}$ near the planar grain boundaries (GB), oriented at the angle θ to the rolling direction (RD) in the grain-oriented silicon steel sheets, which are magnetized to induction 1.5-2.0 T in the external homogenous field $\vec{H}^e$ parallel to the RD were investigated. Calculations of volume energy density f_S of magnetostatic stray field $\vec{H}^m$, associated with the GB were carried out using the scalar magnetic potential theory for the case of one-dimension distribution of magnetization $\vec{M} = \vec{M}(\xi_1)$. Numerical results of $\vec{H}^m$ field components and energy f_S (see fig.; $\xi_1 = 0$ is the planar GB) obtained for the sheets with $(01\bar{1})$ orientation are compared with the corresponding experimental data. Some peculiarities of magnetic interaction between the neighboring grains with a different easy direction <100> orientation in three-axes ferromagnetic such as Fe-3%Si are discussed on the basic of determined results.



Fr-PB107

NUCLEATION PROCESS UPON DEFECTS IN COMBINED-ANISOTROPY MAGNETS

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It is a known fact that the nucleation of magnetic inhomogeneities of various topologies is possible in the defect area of the crystalline lattice, these inhomogeneities substantially influencing the properties of the materials under study. In particular, defect-localized magnetic inhomogeneities act as nuclei of a new phase at phase transitions of the spin re-orientation type [1].

The paper, within the framework of the variational model, investigates the structure and stable states of 0° domain walls in the (011) crystal plate which combines the induced uniaxial anisotropy and the natural cubic one. It has been shown that if one takes into account the plate's demagnetizing fields, arising due to the finiteness of the plate thickness, and if certain types of defects are present, these inhomogeneities become stable formations and exist within the certain ranges of material parameter variations. The dependencies of energy and 0° domain wall dimensions obtained by the authors enable one to determine the quasi-stationary kinetics of the magnet's spin-reorientational phase transition from the state with **M** || [011] to the state **M** || [0uv] with the nucleation of a new phase upon defects.

[1] V.K. Vlasko-Vlasov, M.V. Indenbom // JETP v.86, No3, p.1084 (1984)

Fr-PB108

DOMAIN RESTRUCTURING IN A FERRITE-GARNET (111) PLATE IN A MAGNETIC FIELD

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The domain structure of ferrite-garnet films is known to have a complex nature, which is explained by the influence of various factors, among which is the presence in them of two anisotropy types of different natures – the natural cubic anisotropy and the induced uniaxial one. In particular, the experimental research into the remagnetization processes of (111)-oriented films shows [1] that domain restructuring in the magnetic field $\boldsymbol{H} \parallel [111]$ takes place not only due to the variation of domain structure parameters, but also through a leap-wise change in the direction of the magnetization vector $\boldsymbol{M}$ in reverse domains.

The paper aims at a theoretical research of the equilibrium directions of the vector $\boldsymbol{M}$ in a magnetic field. The conditions have been identified under which such restructuring is made possible. The authors have constructed an effective domain structure model, which, when numerically minimized, enables one to determine the critical value of the restructuring field, this value agreeing well with the experimentally obtained data.

[1] Kandaurova G.S., Pamyatnykh L.A., Shamsutdinov M.A., Filippov B.N. // FMM **31**, Vol. 4, 132 (1989), p.26-44.

Fr-PB109

REMAGNETIZATION PROCESS OF (001)-ORIENTED FILMS CONTAINING DEFECTS

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The authors have performed a theoretical study of nucleation conditions of 0° domain walls and their static properties in a plate of the (001) cubic ferromagnet with inhomogeneous parameters which describe the defects of the planar magnetic inclusion type. Such magnetic inhomogeneities are the model representation of the magnetization $\vec{M}$ distribution in the area of the real crystal [1] and can be used when the processes of their magnetization are investigated. It has been shown that the stability area of 0° domain walls in a magnetic field in the finite thickness plate is bounded by the field's upper limit, above which they either collapse, or diffuse. It has been found that the critical values of the fields are substantially dependent on the contributions of the plate's demagnetizing fields, on the values of material parameters of the sample, as well as on defect characteristics. These fields have been demonstrated to determine the coercive force of the material under study and to have the values comparable to those obtained experimentally.

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Fr-PB110

PARAMETERS OF MAGNETIC DYNAMIC SPIRAL DOMAINS IN MONOCRYSTAL FERRIT–GARNET AND AMORPHOUS Gd-Co FILMS

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Conditions of existence, configuration and parameters of magnetic dynamic spiral domains in uniaxial ferrit - garnet and amorphous Gd-Co films have been studied.
The dynamic spiral domains were found to exist in amorphous Gd-Co films in the narrow temperature ranges below end above the magnetization compensation point. The diagrams of formation of dynamic spiral domains on frequency - amplitude of ac magnetic field were plotted. The similarity and difference of the dynamic domain structures of ferrit - garnet and Gd-Co films were studied. The necessary conditions of the spiral domains formation, in particular, absence of flexural instability of spiral domain at magnetization reversal were discussed.
The effect of the domain wall coercivity on the formation of the spiral dynamic domain at action of a sinusoidal magnetic field was analyzed. The formation model of single spiral domain with disorder nucleus taking into account gyrotropic force and domain wall coercivity was offered. It has been shown that the threshold frequency of formation of spiral dynamic domains is proportional domain wall coercivity. The formula explaining frequency dependence of nucleus sizes was derived. This formula gives qualitative consent with the experiment.

Fr-PB111

DOMAIN WALL MOBILITY IN LOW LOSS GARNET FILMS

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The relation between the domain wall mobility and the energy losses in FMR was studied in YBiFeGa (111) uniaxial magnetic garnet films with narrow FMR line. The mobility was determined using high-speed imaging. A dc magnetic field H_p was applied in the film plane and this field was varied up to 0.4 of the uniaxial anisotropy field. It follows from the analyses of obtained and published data that if the reduced Landau-Lifshitz damping parameter Λ_{FMR}, obtained from FMR measurements, exceeds a small boundary value ($\sim 3 \cdot 10^9$ $Oe^2 \cdot s$), the measured domain wall mobility agrees well with the classical relation, by which mobility is inversely proportional to Λ_{FMR}. It follows from our data that in the region below the boundary value of the damping parameter the classical relation is not valid and the measured mobilities are markedly smaller then the calculated ones. The mobility even decreases with the decrease of Λ_{FMR}. An explanation of mobility behavior in low loss samples was suggested by the theory [1]. According to this theory, the wall motion gives rise to an additional energy loss contribution which may exceed the losses existing in the uniform precession. However, we found that the theory predicts a dependence of wall mobility on the field H_p differing from the relation following from our experiment. Another explanation follows from the general theory of domain wall motion, but the predicted mobility is several orders of magnitude smaller than the experimental value.

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Fr-PB112

MAGNETIZATION PROCESSES IN Sm-Fe-N / α-Fe NANOCOMPOSITIES

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The nanocomposite $Sm_2Fe_{17}N_x$ / α-Fe compounds ($x \leq 3$) have excellent intrinsic properties for permanent magnet applications. The composite magnets may retain high values of remanence and coercivity when an exchange coupling extends across the interface of the hard ($Sm_2Fe_{17}N_x$) and soft (α-Fe) phases.
However, the magnetization mechanism of these materials is not fully explained. Therefore, the aim of the present study is to obtain further information on magnetization processes in nanocomposite $Sm_2Fe_{17}N_x$ / α-Fe magnets using for the first time for this material the rotational hysteresis energy W_r and its integral R, calculated from torque curves. Moreover, field dependence of the coercivity of minor hysteresis loop was determined.
The studies were carried out on magnets with the following optimal magnetic properties: coercivity H_c=290 kA/m, remanence J_r = 1.07 T, maximum energy product $(BH)_{max}$ = 105 kJ/m^3.
From the field dependence of the rotational hysteresis energy $W_r(H)$ and the value of the rotational hysteresis integral R it follows that the magnetization reversal of nanocomposite $Sm_2Fe_{17}N_x$ / α-Fe magnets seems to be, in general sense, the incoherent mechanism.
Moreover, a linear increase of $_JH_c$ with increasing applied magnetizing field before $_JH_c$ reaches maximum value indicates that coercivity in the studied magnet is controlled by nucleation mechanism.

Fr-PB113

FIRST ORDER MAGNETIZATION PROCESSES IN $TbMn_6Sn_6$

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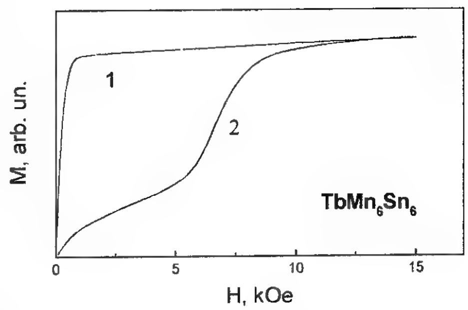
The $TbMn_6Sn_6$ compound (s.g. P6/mmm) is a collinear two-sublattice ferrimagnet with the Curie temperature ~420 K and the spin-reorientation temperature T_{sr}= 330 K. Above T_{sr} the magnetic moments are oriented perpendicular to the *c*-axis, while at 300 K they deviate by the angle 15° from the *c*-axis. The magnetization jump was observed on the magnetization curve of $TbMn_6Sn_6$ at 300 K and was interpreted as either the spin-flop or the metamagnetic transition [1].



We investigate the magnetization and the magnetostriction of the $TbMn_6Sn_6$ compound. The magnetization curves of the oriented powder at 300 K show the difference of magnetization process along (curve 1 in figure) and across (curve 2) of the alignment direction. The linear longitudinal magnetostriction of the bulk polycrystalline sample also reveals an anomaly at the same field as for the magnetization anomaly. The obtained results allow us to consider the magnetization jump in $TbMn_6Sn_6$ compound as the first order magnetization processes (FOMP) rather than the spin-flop or the metamagnetic transition.

[1] Hu J., Wang K.-Y., Hu B.-P., Wang Y.-Z., Wang Z., Yang F., Tang N., Zhao R., and Qin W. // J.Phys.: Condens. Matter, 7, (1995), p.889.

Fr-PB114

NUCLEATION OF MAGNETIC INHOMOGENEITIES IN IRON GARNET FILMS WITH MIXED ANISOTROPY

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The experimental and theoretical investigation of magnetic inhomogeneities nucleation process in ferrite-garnet monocrystal with combined anisotropy was carried out.

The initial stage of the formation of a domain structure, i.e., the nucleation of magnetic inhomogeneities of various spatial configurations near the orientational phase transition in a multiaxial film with a mixed magnetic anisotropy was studied theoretically on the basis of micromagnetic approach. It was shown that depending on the film thickness, the anisotropy constants, and the magnetic field direction, both one-dimensional stripe magnetic inhomogeneities with various stripe orientations and magnetic inhomogeneities that have a two-dimensional spatial structure may nucleate. The experimental investigation of magnetic inhomogeneities nucleation process on (110) and (111) plates of ferrite-garnet $(Tb\ Er\ Gd)_3\ Fe_5\ O_{12}$ monocrystal in planar magnetic field was carried out. The formation of strip-shaped slightly contrasting magnetic inhomogeneities was observed in planar magnetic field near the saturation. The qualitative change of magnetic inhomogeneities shape with the change of crystallographic orientation of magnetic field on the plane was established.

FR-PB115

INSTABILITY OF Co MAGNETISM AND MAGNETOELASTIC PROPERTIES OF THE (Ho,Y)Co_3 COMPOUNDS

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Two metamagnetic transitions, from a weakly magnetic (WM) to an intermediate magnetic (IM) state and from IM to a strongly magnetic (SM) state, occur in the intermetallics YCo_3 (T_C = 300 K, a $PuNi_3$-type rhombohedral structure) in fields 60 and 82 T, respectively. This magnetic instability gives rise to a number of effects in other RCo_3 compounds with magnetic rare earths.
Magnetization and X-ray thermal expansion of the $Ho_{1-x}Y_xCo_3$ system were studied in a wide temperature and concentration ranges. Due to a strong f-d exchange interaction, the Co sublattice is in the SM state in $HoCo_3$ at low temperatures, which can be transformed into the WM state by Y substitution. Temperature induced SM $\rightarrow$ IM/WM metamagnetic transitions were observed in the Ho-rich compounds, the Ho sublattice still remained magnetic. The results obtained can be interpreted within the scope of the molecular field approximation, as effect of the variable intersublattice interaction. The magnetic phase diagram of the $Ho_{1-x}Y_xCo_3$ system includes also spin-reorientation phase transitions occurring due to a competition between the anisotropies of the Ho and Co sublattices. Magnetoelastic constants were determined from the magnitude of the structure distortions.
This work was supported by INTAS project No 96-0630

Fr-PB116

THE EFFECT OF SPIN-REORIENTATION ON THE MAGNETIC DOMAIN STRUCTURE OF $Dy(FeCo)_{11}Ti$ AND $Tb(FeCo)_{11}Ti$ INTERMETALLIC COMPOUNDS

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Single crystals of the intermetallic compounds $Dy(FeCo)_{11}Ti$ and $Tb(FeCo)_{11}Ti$ were used to investigate the influence of magnetocrystalline anisotropy on the magnetic domain structure. By means of torque technique in the given compounds the following anisotropy types were found: easy axis, easy cone, easy plane, easy axis + easy plane, easy plane + easy axis [1]. The first investigations of the magnetic domain structure transformation near the spin-reorientation temperatures T_{SR} was performed. The spin-reorientation phase diagrames of $Dy(FeCo)_{11}Ti$ and $Tb(FeCo)_{11}$ intermetallic compounds was built. The influence of magnetic domain structure on the nature of the phase transitions was investigated.
The principal difference in the magnetic domain structure changes for the magnetic phase transition of the first- and second order was found. The models for the change in the magnetic domain structure during the spin reorientation for both types of transition in tetragonal crystals are discovered.
In conclusion, it may be said that the domain structure observation in the spin reorientation regions is a good way for clarifying of the magnetic phase transition nature and useful for the development of micromagnetic models of domain structure.

Fr-PB117

MAGNETIC AND MAGNETOELASTIC PROPERTIES OF $Tb_xDy_{1-x}Fe_2H_y$ HYDRIDES

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The crystal structure, magnetic and magnetoelastic properties of $Tb_xDy_{1-x}Fe_2H_y$ (x=0;0,27;0,41; y≤3) has been investigated. The hydrides was obtained by the interaction of the $Tb_xDy_{1-x}Fe_2$ samples with hydrogen gas at room temperature. The concentration of absorbed hydrogen in the samples was calculated using the Van-der-Waals equation and additionally was measured by full burning method. It is established that hydrides have the same cubic type structure as the parent compound but the lattice parameter in the hydrides increased compared with the hydrogen free sample. Both Curie temperature and the magnetic moment decrease when x increases that agree well with data obtained earlier [1].
The measurements of longitudinal $\lambda_{\parallel}$ and transversal magnetostriction. $\lambda_{\perp}$ were carried out in magnetic fields up to 1.2 T in the temperature range 78-300 K using strain gauges. Thermal expansion coefficients as a function of temperature near T_C were obtain for hydrides with high concentration hydrogen. The magnetostriction of hydrides is strongly different from that of hydride-free samples. The small and even negative value of magnetostriction proves that hydrogen atoms make the strong contributed to the crystal field acting into R ions. The work has been supported by RFBR Grant N99-02-17821 and N99-03-32824.

[1] Yermakov A.Ye., Mushnikov N.V., Zajkov N.K., Gaviko V.S. and Barinov V.A. // Philosophical Magazine B 68(6), (1993), p.883.

Fr-PB118

MAGNETIC PROPERTIES AND ATOMIC STRUCTURE OF RARE-EARTH AMORPHOUS ALLOYS

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Correlation between atomic disorder and magnetic order in non-crystalline (amorphous) metals is one of the most interesting and important problems of modern physics of magnetic phenomena. The purpose of this work was the investigation of atomic structure and magnetic properties of Re-T^{4f} (T^{4f} = Tb, Dy, Ho, Er) amorphous alloys prepared by sputter deposition.
The temperature dependence (4.2-300 K) of low-field ac susceptibility $\chi(T)$ and dc magnetization M(T) of Re-T^{4f} amorphous alloys have been measured. In all alloys a maximum on the dependence $\chi(T)$ and irreversibility of magnetization M(T) indicative of the spin-glass like transition were found. The transition temperature T_0 decreases with increasing the number of 4f electrons of rare-earth atoms. The transition is observed only in the alloys containing more than 20 % of rare-earth atoms, i. e. the magnetic ordering is observed only above the percolation threshold in these systems. Furthermore, the concentration dependence of T_0 is universal, i. e. it is determined not by specific parameters of atomic structure of these alloys, but by cluster distribution by sizes which is common for all systems [1].

[1] Barmin Yu.V., Bataronov I.L., Bondarev A.V. X-ray Diffraction Study and Computer Simulation of Atomic Structure of Rare-earth and Transition Metal Amorphous Alloys // this conference.

Fr-PB119

EFFECT OF Ga SUBSTITUTION ON THE FORMATION STRUCTURE AND MAGNETIC PROPERTIES OF MECHANICALLY ALLOYED Sm-Fe-N MAGNETS

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One of the most promising modern hard magnetic materials which exhibits outstanding magnetic properties, is magnets produced on the basis of Sm-Fe-N alloys. The composition $Sm_2Fe_{17}N_x$ (x=2-3) obtained by mechanical alloying has good magnetic properties (T_c=470°C; J_s=1.5 T; H_c=2000 kA/m; $(BH)_{max}$=450 kJ/m^3). The alloys doped with Ga were studied to improve the magnetic properties and decomposition temperature of the phase $Sm_2Fe_{17}N_x$. The magnetometrical, X-ray diffraction and electron microscopy with microanalysis studies have shown that 0.5 at.% Ga doping lead to the formation of substitution hard solution and the improvement of the alloy's magnetic properties.

Fr-PB120

MAGNETIC PROPERTIES OF INTERMETALLICS IN Ho-Fe SYSTEMS AT HIGH TEMPERATURE

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Temperature dependencies of magnetic susceptibility $\chi(T)$ of holmium, iron and possible compounds between them $HoFe_2$, $HoFe_3$, Ho_6Fe_{23}, Ho_2Fe_{17} in wide range of temperatures (20-1700 C) in the solid and the liquid states were experimentally studied by Faraday method. The experimental results showed that the dependence $\chi^{-1}(T)$ of pure metals is described by Curie-Weiss law in both the solid and the liquid state. During the polymorphic transformations and melting of holmium the dependence $\chi(T)$ was not changed essentially but for iron it is changed with sharp jumps. The dependence $\chi(T)$ for the studied compounds in the solid state had a complicated character. With increasing of temperature the susceptibility increases at first and it reaches its peak values at 715, 705 and 710 C for Ho_6Fe_{23}, $HoFe_3$ and $HoFe_2$, respectively, and then it decreases. Furthermore, close to these temperatures the increasing of the magnetic field decreases the susceptibility of theses compounds. These two experimental features indicate that these compounds are related with antiferromagnetics and their dependence $\chi(T)$ in the paramagnetic phase is described by Neel law. The Neel law parameters characterizing the exchange interactions between sublattices of compounds have been estimated from the experimental dependence $\chi(T)$ of these compounds.

Fr-PB121
MAGNETOELASTIC PROPERTIES OF Gd_2In

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Magnetostriction measurements, parallel ($\lambda_{||}$) and perpendicular ($\lambda_{\perp}$) to the applied magnetic field, of the Gd_2In compound from 5 to 290 K have been performed using applied magnetic fields up to 5 Tesla in a polycrystalline sample.
The magnetic structures of Gd_2In are not completely well known. This is a layered intermetallic compound displaying 3 different magnetic phases below room temperature [1]. Below 100 K, this compound shows antiferromagnetic [2] or ferrimagnetic [1] order and ferromagnetic [1] or helical ferromagnetic [2] order between 100 and 199 K. Above 199 K the compound is a paramagnet [1,2]. The low temperature state (LTS) can be transformed to a simple ferromagnetic state by an applied magnetic field giving rise to metamagnetic transitions as observed in magnetization [1] and magnetoresistance measurements [3].
A similar behaviour has been observed in our magnetostriction measurements in which sharp jumps have been seen at some critical fields. We have also obtained that the magnetostriction in the LTS is of volume ($\omega = \lambda_{||} + 2\lambda_{\perp}$) only, the anisotropic one ($\lambda_t = \lambda_{||} - \lambda_{\perp}$) being negligible. As no anomaly has been observed in the volume thermal expansion, our measurements suggest that the intermediate temperature phase is not a simple ferromagnetic state.

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[2] C-S Jee, C.L. Lin, T. Mihalisin and X-Q Wang // J. Appl. Phys. 79 (1996) p.5403
[3] P. A. Stampe et al // J. Phys.: Condens. Matter 9 (1997) p.3763

Fr-PB122
NEUTRON DIFFRATION STUDIES OF THE MAGNETIC STRUCTURES OF $TbRhRuSi_2$ and $TbRh_{1.2}Ru_{0.8}Si_2$ COMPOUNDS

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The magnetic structures of the $TbRhRuSi_2$ and $TbRh_{1.2}Ru_{0.8}Si_2$ compounds have been investigated by neutron diffraction measurements.These compounds crystallize in a $ThCr_2Si_2$ -type tetragonal structure and are antiferromagnets with the Néel temperature equal 15.5K for $TbRhRuSi_2$ and 10K for $TbRh_{1.2}Ru_{0.8}Si_2$. The magnetic structure of $TbRhRuSi_2$ is described by a sine-modulated spin wave with a wave vector **k** = (0.445, 0, 0). The magnetic moment localized on terbium amounts to 10.16(14) μ_B at 1.5K and its aligned along the c-axis. For the $TbRh_{1.2}Ru_{0.8}Si_2$ compound two sine-wave modulated magnetic phases coexist: one described by **k** = (0.445, 0, 0) and the other one by **k** = (0.5, 0.5, 0.5).

Fr-PB123
EFFECT OF EXCHANGE INTERACTIONS ON Co AND Ni MOMENTS IN RARE - EARTH COMPOUNDS

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As a result of a large number of substitutions which can be performed on R-M-B or R-M-based compounds, where R is a rare-earth and M = Co or Ni, the exchange interactions can be modified in a large range of values [1]. Strongly connected with the exchange fields acting on M atoms, a wide range of behaviours can be observed, from well established magnetism to paramagnetism by crossing the situation in which magnetism is close to an onset or collapse. We studied the magnetic properties of a large number of pseudobinary or pseudoternary rare-earth compounds. In case of exchange enhanced paramagnets a spin fluctuation type behaviour is evidenced. Above a characteristic temperature, the magnetic susceptibilities follow a Curie-Weiss dependence with effective moments close to those of free ions. The increase of the exchange interactions and appearance of induced M moments leads to a gradual quenching of spin fluctuations. The M moments, at 4.2 K, in magnetic ordered compounds, show a metamagnetic - type transition for a critical field, H_{cr}. Then, the moments increase linearly with the exchange fields and finally saturate. The effective M moments were also determined. A good agreement between the magnetic behaviour of M elements obtained from band structure calculations and those experimentally determined is shown.

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Fr-PB124
MAGNETIC AND ELECTRONIC PROPERTIES OF $Gd_xLa_{1-x}Ni_5$ SYSTEM

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The magnetic properties of $Gd_xLa_{1-x}Ni_5$ were studied in temperature range 1.5 K - 300 K. The magnetic susceptibility of $LaNi_5$, at $T \leq 10$ K, follows a T^2 dependence. At $T \geq 170$ K a Curie - Weiss type behaviour is evidenced. The effective nickel moment of 2.1 μ_B/Ni atom suggests that $LaNi_5$ is a nonsaturated spin fluctuation system. When La is gradually substituted by Gd, a magnetic moment is induced on nickel atoms, which increases up to $M_{Ni} \cong 0.12\ \mu_B$ for x = 1. The effective nickel moments decrease when increasing gadolinium content. This behaviour was attributed to quenching of spin fluctuations by internal fields. The band structure calculations describe well the experimental data. For example, a magnetic moment of 6.45 μ_B/f.u. was calculated in case of $GdNi_5$, in good agreement with experimental value (M = 6.43 μ_B at 1.5 K).

Fr-PB125

INFLUENCE ON THE INTERSUBLATTICE EXCHANGE INTERACTION OF THE SUBSTITUTION OF Fe BY Al IN $GdFe_{12-y}T_y$ (T=Ti, Mo, V) COMPOUNDS

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Three series of alloys with nominal composition $Gd(Fe_{1-x}Al_x)_{11}Ti$ (for x = 0; 0.05; 0.1; 0.2; 0.27), $Gd(Fe_{1-x}Al_x)_{10.5}Mo_{1.5}$ (for x = 0; 0.05; 0.1; 0.15; 0.2) and $Gd(Fe_{1-x}Al_x)_{10}V_2$ (for x = 0; 0.05; 0.1; 0.15; and 0.2) and also the $Y(Fe_{1-x}Al_x)_{11}Ti$, $Y(Fe_{1-x}Al_x)_{10.5}Mo_{1.5}$ and $Y(Fe_{1-x}Al_x)_{10}V_2$ (for x = 0.1 and 0.2) alloys have been prepared by arc melting technique. For the 1:12-type phase, the Curie temperatures have been determined by measuring the temperature dependence of magnetization of alloys in a weak external magnetic field (40.9 mT) by plotting $M^2(T)$. The microscopic exchange coupling parameters A_{RT} and the macroscopic molecular field coefficients n_{RT} and n_{TR} have been calculated based on the analysis of the Curie temperature expression in the molecular field approximation (MFA)[1]. In both of the cases, the R-T exchanges parameters clearly and nonlinearly decreases with aprox. 30% (T=Ti), 34%(T=Mo) and 41%(T=V). The variation of the strength of the intersublattice exchange interaction has been analyzed in function of the total diamagnetic (Al + M) ions concentration and explained in terms of 3d-3p hybridization, which is followed by a change of 3d-5d hybridization [2].

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[2] C.B. Cizmas, Proceeding of International Satelite meeting on Frontiers in Magnetism FIM-99, Aug. 12-15, 1999, Stockholm, (Sweden), p.P06.

Fr-PB126

MAGNETISM IN Er_6Ni_2Sn

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We report on structure, magnetic and transport properties measured on polycrystals of a novel material Er_6Ni_2Sn. This compound crystallizes in the orthorhombic Ho_6Ni_2Ga-type structure with lattice constants $a = 9.245$ Å, $b = 9.417$ Å and $c = 9.819$ Å. The temperature dependence of electrical resistivity exhibits two pronounced cusp-like anomalies at $T_1 \approx 18$ K and $T_N \approx 35$ K. Magnetization and specific heat data with respect to temperature and magnetic field confirm that these anomalies are connected with magnetic phase transitions. Magnetization curves measured in magnetic fields up to 5 T at different temperatures exhibit no spontaneous magnetic moment. At 5 K, a metamagnetic transition having the onset around 1 T is observed. This transition is lifted up to ≈ 1.3 T when temperature increases above 18 K; then it persists up to ≈ 30 K, although it gradually becomes broader and less pronounced with increasing temperature. The temperature dependence of susceptibility above 50 K is well described by a Curie-Weiss law with $\mu_{eff} = 9.72\ \mu_B$ (which is very close to Er^{3+} free-ion moment) and $\Theta_p = 3.13$ K.
On the basis of magnetic, resistivity and specific heat study we consider the following scenario for Er_6Ni_2Sn: it becomes antiferromagnetic below $T_N \approx 35$ K and undergoes a rearrangement of magnetic structure around 18 K. The metamagnetic transition above 1 T (1.3 T at temperatures above 18 K) observed on magnetization curves is apparently connected with a relatively easy collapse of antiferromagnetism under applied magnetic fields.

Fr-PB127
THE MAGNETIZATION PROCESSES AND SPIN-REORIENTATION TRANSITIONS IN $Dy(FeCo)_{11}Ti$ SINGLE CRYSTALS.

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The $DyFe_{11-x}Co_xTi$ (x=0, 1, 2, 3) single crystals were investigated in order to elucidate the influence of substitutions Fe by Co in the sublattice of the transition metal upon the character of the spin-reorientation transition (SRT) and the magnetization. of these compounds. The samples of $DyFe_{11-x}Co_xTi$. compounds having the $ThMn_{12}$-type structure were studied by using the torque and magnetization measurements .The torque curves were obtained .in the temperature range 77K-300K and in magnetic field up to 1.2T .The magnetization measurements were performed in magnetic field up to 14T at the temperature from 4.2K to 300K, and in magnetic field 1.2T at the temperature from 77K to 750K. The $DyFe_{11-x}Co_xTi$ single crystals demonstrated spin-reorientation transition from the easy axis to the easy plain via cone with a temperature lessening. The substitution of Co for Fe produce an enhance of the Curie temperatures, a decrease temperatures of SRT and an appearance of the first order magnetization processes.

Fr-PB128
MAGNETIC ORDERING IN HoNiAl

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HoNiAl belongs to a large group of RTX intermetallics (R = rare earth, T = transition metal, X = p-metal) crystallizing in the ZrNiAl-type hexagonal structure (space group P-62m). HoNiAl orders magnetically below T_{ord} = 14.5 K. As inferred from neutron powder diffraction, the magnetic structure consists of two components: ferromagnetic one oriented along the c-axis, and an antiferromagnetic (AF) one, described by a propagation vector $\boldsymbol{k}$ = (1/2, 0, 1/2) [1,2]. An additional magnetic phase transition at $T_1 \cong 5$ K is connected with a reorientation of the AF component. Results concerning this AF component, arising from the two independent powder diffraction experiments [1,2], are considerably different. In order to solve this disagreement, we have performed magnetization measurements and a neutron diffraction experiment on HoNiAl single crystal. We have confirmed the existence of the two magnetic phases. The ferromagnetic component along the c-axis exists in both phases, in agreement with the former data. Surprisingly, in distinction to powder data, the AF component with $\boldsymbol{k}$ = (1/2, 0, 1/2) has not been observed in the magnetic phase between T_1 and T_{ord}. It develops below T_1 only. We describe here the corresponding magnetic structure in details.

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Fr-PB129

ORIGINAL MAGNETIC PHASE DIAGRAM OF $Ce_2Fe_{17-x}Mn_x$ ALLOYS

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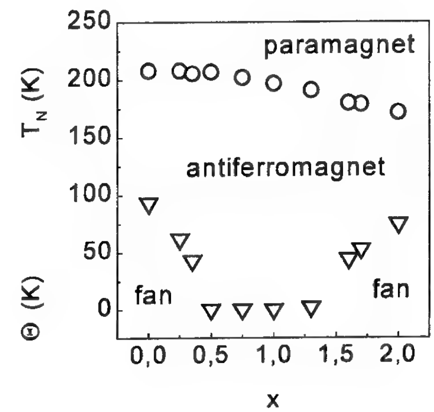
The magnetic and structural properties of $Ce_2Fe_{17-x}Mn_x$ alloys with x=0-3 were studied by magnetic measurements, X-ray and neutron diffraction techniques. The lattice constants increase with increasing Mn content except in a region of weak decrease around x=1.7. The Mn atoms favor 6c site, avoid 9d site and randomly occupy 18f and 18h sites. The magnetic phase (x-T) diagram of $Ce_2Fe_{17-x}Mn_x$ system is drawn in Figure. The $T_N(x)$ dependence is almost monotonic whilst Θ vanishes in the interval x=0.5-1. Binary alloy Ce_2Fe_{17} exhibits fan magnetic structure below Θ and helical antiferromagnetic one in the Θ-T_N range because of the very short Fe-Fe distances in this alloy [1]. The exchange interactions between nearest neighbour Fe atoms can be positive (r_{FeFe}>0.25 nm) or negative (r_{FeFe}<0.25 nm) [1]. It is known that the interactions Fe-Mn, Mn-Mn and Fe-Fe have the same distance-dependent character. Therefore the obtained original magnetic phase diagram of $Ce_2Fe_{17-x}Mn_x$ system can be interpreted on the basis of competition of these interactions, and Mn preferential occupancy must be taken into consideration.



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Fr-PB130

MAGNETIC PHASE TRANSITIONS AND MAGNETORESISTANCE IN $(Tb_{1-x}Y_x)_3Co$ SYSTEM

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The systematic study of the magnetization, magnetoresistance and magnetostriction of $(Tb_{1-x}Y_x)_3Co$ single crystals with the orthorhombic Fe_3C type structure has been performed. The energy of magnetocrystalline anisotropy in these compounds exceeds the energy of RKKY exchange interaction and the low symmetry crystal field supports an appearance of the noncollinear magnetic structures below the ordering temperature. Co atoms do not carry the magnetic moments. At $x < 0.3$ the magnetic moments of Tb ions form the magnetic structure with a strong ferromagnetic (F) component along the **c** axis and antiferromagnetic (AF) components along **a** and **b** axes. The magnetic field applied along **a** and **b** axes induces the first order magnetization process (FOMP) which is accompanied by a giant magnetoresistance effect ($|\Delta\rho/\rho|$ ~35%) and magnetostriction (up to 10^{-3}) which are strongly anisotropic. FOMP in $(Tb_{1-x}Y_x)_3Co$ can be associated with switching of the orientation of local directions of Tb magnetic moments. Both the magnetoresistance and magnetostriction show a significant hysteresis and irreversibility. A large difference in the electrical resistivity in phases with the different magnetic structure and an additional maximum observed in the intermediate state are discussed in terms of superzone effects and s-electron reflection from the potential barrier at the interphase boundary. An increase of the Y content up to $x \geq 0.3$ causes a rearrangement of the magnetic structure from the initial to a complex noncollinear AF structure.

Fr-PB131
MAGNETOVOLUME EFFECTS IN Ce_2Fe_{17} COMPOUND

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The magnetisation, magnetic susceptibility, electric resistivity and thermal expansion of the polycrystalline intermetallic compound Ce_2Fe_{17} were studied under hydrostatic pressures up to 10 kbar at temperatures from 10 K to 300 K. At ambient pressure the compound is a noncollinear ferromagnet below $\Theta_T = 94$ K and an antiferromagnet for $\Theta_T < T < T_N$, $T_N = 206$ K. The temperatures of magnetic transitions are well pronounced as anomalies on the magnetic susceptibility, electric resistivity and thermal expansion temperature dependencies.
The giant negative pressure effect on Θ_T was determined: $d\Theta_T/dP = -(38 \pm 2)$ K/kbar. The ferromagnetic state is suppressed by pressure of $P_C = 2.5$ kbar. The pressure effect on the Neel temperature $T_N = 206$ K is significantly smaller: $dT_N/dP = -(1.7 \pm 0.2)$ K/kbar [1]. The large positive spontaneous volume magnetostriction observed below T_N is suppressed by application of high pressure and disappears for $P > P_c$. The initial volume compressibility in magnetically ordered states increases four times in comparison to the paramagnetic state. The results show a strong correlation between magnetic properties and the lattice volume. Possible competition of positive and negative exchange interactions between iron atoms and/or a valence instability of Ce can be considered as reasons for such correlation.

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Fr-PB132
PRESSURE EFFECT ON MAGNETIZATION AND ANISOTROPY IN $DyFe_{11}Ti$ SINGLE CRYSTAL

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We have done series of experiments to determine the behavior of magnetization and ac-susceptibility of the $DyFe_{11}Ti$ compound under high pressure (up to 10 kbar) and high magnetic fields (up to 5T) in temperature range 5-300 K. The single crystals were oriented along easy (001) and hard direction (100) of magnetization.
Decrease of the saturation magnetization with increasing pressure was observed in whole temperature range studied ($d\ln M_{S[110]}/dp = -0.0063$ kb^{-1}). Almost identical values of $d\ln M_S/dp$ were obtained in $YFe_{11}Ti$ and $HoFe_{11}Ti$ single crystals [1], [2]. This result confirms assumption that the Fe magnetic sublattice is responsible for the pronounced magnetovolume effects in *R*-Fe intermetallics. Competition between the Dy and Fe sublattice anisotropy yields two spin reorientation transitions (SR) at $T_{SR1} = 131$ K and $T_{SR2} = 226$ K. Both of the T_{SR} decreased with increasing pressure with d $T_{SR1}/dp = -1.61$K/kb and d $T_{SR2}/dp = -1.27$K/kb, respectively.
A complex behavior of the magnetocrystalline anisotropy of the $DyFe_{11}Ti$ compound under pressure and a possible pressure induced magnetic phase transition at low temperature will be discussed.

[1] Mikulina O., et al, J. Magn. Magn. Matter. **196-197** (1999), 649
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Fr-PB133
MAGNETIC PROPERTIES OF $Gd_xCe_{1-x}Co_4M$ COMPOUNDS WITH M = B OR Si

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The $Gd_xCe_{1-x}Co_4M$ system crystallizes in $CeCo_4B$ - type structure while in case of $Gd_xCe_{1-x}Co_4Si$ compounds a $CaCu_5$ - type lattice is evidenced. Magnetic measurements were performed in the temperature range 1.5 - 1000 K and fields up to 7 T. The compounds are ferrimagnetically ordered. At 1.5 K the compensation compositions are at x = 0.3 for M = B and 0.37 for M = Si. The mean cobalt moments, as well as the Curie temperatures are strongly dependent on composition. In some samples metamagnetic - type transitions were evidenced. The exchange interactions between and inside magnetic sublattices, as well as the exchange fields acting on cobalt atoms were computed. The cobalt moments show a rapid increase around H_{exch} E 50 T and then are linearly dependent on the exchange fields. Finally, we analyze the experimental data in the model of induced magnetism [1].

[1] E.Burzo, J. Less. Common Met. 77 (1982) 251

Fr-PB134
A μSR STUDY OF SPIN FLUCTUATIONS IN $Hf_{1-x}Ta_xFe_2$ INTERMETALLICS

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The ground state of the $Hf_{1-x}Ta_xFe_2$ intermetallic compounds is ferromagnetic (F) for $0 \leq x < 0.3$, antiferromagnetic (AF) for $0.3 \leq x \leq 0.7$, and Pauli paramagnetic at around x=1 [1]. Within the concentration range $0.1 < x < 0.3$, these systems undergo a AF-F first-order magnetic transition with decreasing temperature, which is accompanied with a change in volume ≈1.2%, magnetic entropy ≈1.2 J/mol, and a change in resistivity of ≈40% [1]. The effect of applying an external magnetic field in the AF phase is to induce a transition to the F state through a first-order magnetic phase transition. Therefore, these systems present a giant volume magnetostriction, magnetoresistance and magnetocaloric effect tunable near room temperature, making these alloys potential candidates for technological applications.
Despite all the extensive experimental and theoretical work, the origin of the AF-F transition is still unclear. Muon spin relaxation (μSR) has proved to be an ideal microscopic probe to study the role and evolution of the spin fluctuations in itinerant electron systems. In our compounds, a significant difference in the muon spin relaxation rate $\lambda(T)$ has been found in x=0.1 (AF) and x=0.3 (F). The existence of an AF-F transition in the x=0.2 compound will be discussed in terms of competition between AF and F spin fluctuations.

[1] Y. Nishihara and Y. Yamaguchi // J. Phys. Soc. Jpn., 51, (1982) p. 1333; *ibid.* 52, (1983) p. 3630; H. Wada, N. Shimamura, and M. Shiga // Phys. Rev. B, 48, (1993) p. 10221

Fr-PB135
MAGNETOVOLUME EFFECT IN UX_3 COMPOUNDS

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Experimental study of the magnetic susceptibility χ of the uranium compounds UX_3 (X=Si, Ga, Ge) under pressure up to 2 kbar in the temperature range 78-300 K reveals a pronounced pressure effect. The measured volume derivatives $d\ln\chi/d\ln V$ were found to be nearly temperature independent and equal to 2.5, 6 and 6.5 for USi_3, UGa_3, and UGe_3, respectively. In order to analyze the experimental data, the volume dependent electronic structures of UX_3 have been calculated *ab initio* in the paramagnetic phase by employing a relativistic full-potential LMTO method. The effect of external magnetic field was included self-consistently by means of the Zeeman operator, as well as orbital polarization. The calculations have brought out a predominance of itinerant uranium $5f$ states at the Fermi energy, as well as competing the orbital and spin contributions to χ. The calculated field-induced magnetic moments of UX_3 and their volume derivatives agree well with the experimental results.

Fr-PB136
LOW TEMPERATURE MAGNETIC STATES OF Ce-Ni-Ge COMPOUNDS

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A complex study of electric, magnetic, and thermal properties has been done on an antiferromagnetic (AFM) series of Ce-Ni-Ge intermetallic compounds: Ce_2NiGe_6 (216), $Ce_3Ni_2Ge_7$ (327), $CeNiGe_3$ (113), and $Ce_2Ni_3Ge_5$ (235). Magnetic susceptibility data display low temperature anomalies due to AFM transitions at 7K and 10K (216), at 7K (327), and at 4.2K (113 and 235). Low temperature (0.3÷20K) specific heat C_p measurements on 216, 327, and 235 revealed even more pronounced peaks (with weak satellites in 327 and 235). The measurements on electric resistivity $\rho(T)$ indicate the same features in $d\rho(T)/dT$ for 216, 327 and 113. Besides, a broad feature from crystal field splitted Ce levels is observed for $\rho(T)$ and Seebeck coefficient $S(T)$ in these materials. Also the values of $\Delta\rho/\rho$ and ΔS under applied magnetic field up to 9 kOe reveal these two kinds of contributions for 216 and 327 compounds.
Analysis of experimental data permitted to evaluate the effective mass range $\sim 10m_e$ (216) to $\sim 100m_e$ (235), consistent with gradual transition from AFM to heavy fermion regime, and a specific C_p anomaly in 235 is compared with that known for CeNiCu. Estimated crystal field parameter Δ ~35K, included into a simple model together with Heisenberg exchange $J \ll \Delta$, permitted to conclude about possible dimensional (3D→2D) magnetic transition at 7K in 216.

Fr-PB137
HIGH PRESSURE EFFECT ON MAGNETIC PROPERTIES OF $Ce_2Fe_{17-x}Mn_x$

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The substitution of Fe by Mn leads to the negligible changes of the lattice parameters and to the significant changes of the magnetic properties of the Ce_2Fe_{17} compound [1]. To characterize the role of volume in the more detail, we performed high hydrostatic pressure studies (up to 10 kbar) of the magnetization, ac-susceptibility and thermal expansion of polycrystalline $Ce_2Fe_{16.65}Mn_{0.35}$ and $Ce_2Fe_{16}Mn_1$ compounds in the temperature range 10 -300 K.
The Mn substitution leads to a significant narrowing of the stability range of ferromagnetic state, characterizing by $\Theta_T = 48$ K for $Ce_2Fe_{16.65}Mn_{0.35}$ (94 K for Ce_2Fe_{17}). The pressure effect on Θ_T is slightly smaller in comparison with "pure" Ce_2Fe_{17} [2], $d\Theta_T/dp = -30$ K/kbar. The large positive spontaneous volume magnetostriction is suppressed by application of high pressure and disappears for P > 1.5 kbar. No ferromagnetic order was observed for $Ce_2Fe_{16}Mn_1$. The effect of pressure on Neel temperature increases with increasing Mn content, $dT_N/dp = -2.2$ K/kbar for $Ce_2Fe_{16.65}Mn_{0.35}$ and $d/T_Ndp = -3.5$ K/kbar for $Ce_2Fe_{16}Mn_1$. Re-entering increase of ac-susceptibility was observed at pressures higher than 4.4 kbar below 80 K for $Ce_2Fe_{16}Mn_1$. The results show not only a strong correlation between magnetic properties and the lattice volume but also the significant role of the Mn content.

[1] Kuchin A., Khrabrov V., Ermolenko A., Belozerov E. Phys.Metals Metallogr. (2000) in print.
[2] Medvedeva I., Arnold Z., Kuchin A., Kamarad J. J.Appl.Phys. (1999) in print

Fr-PB138
CRYSTAL-FIELD INTERACTIONS IN $ErRu_2Si_2$

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$ErRu_2Si_2$ is antiferromagnetic below 6 K. It exhibits enormous magnetic anisotropy. A field of 6T applied along the tetragonal c-axis (the hard direction) induces only 5 % of the moment observed along the easy axis <110>. It points to the anisotropy field of more than 120 T. We have performed calculations of the fine electronic structure of the Er^{3+} ion in the tetragonal symmetry, relevant to $ErRu_2Si_2$, taking into account crystal-field and inter-site exchange interactions.
Our calculations reproduce well the temperature dependence of the heat capacity together with the λ-type of peak at T_N. We have calculated the local magnetic moment as the function of the magnetic-field direction that is in very good agreement with the macroscopically-measured magnetization curves.
The evaluated crystal-field interactions for $ErRu_2Si_2$ are consistent with that earlier determined for isostructural $PrRu_2Si_2$.

Fr-PB139
FIELD INDUCED PHASE TRANSITIONS OF $R_6Fe_{13}X$ COMPOUNDS $R = Nd, Pr; X = Sn, Si, Sb, Pd, Au$

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Compounds of the general type $R_6Fe_{13}X$ are formed, if during the production of Nd-Fe-B or Pr-Fe-B permanent magnets elements like Sn, Si, Sb, Pd, Au (X) are admixed. Since these compounds may enhance the coercivity of such magnets, the knowledge of their magnetic properties is essential. R is situated on two and Fe on four crystallographically different lattice sites [1]. We report on magnetic measurements in fields up to 14.5 T and temperatures between 2 and 290 K as well as on Mössbauer measurements in fields up to 13.5 T at 4.2 K. A tendency for saturation with moment of 37.5 μ_B/FU is observed for $R_6Fe_{13}Pd$ at low temperatures in fields above 12 T. Contrary for the compounds containing Au or Sb no saturation and moments of only 19 μ_B/FU or 14 μ_B/FU are obtained at comparable fields and temperatures, respectively. For both R elements Nd and Pr step like changes of the magnetisation are observed, indicating a change of the spin structure with field. This behaviour contradicts partly the simple antiferromagnetic spin arrangement proposed from neutron diffraction studies [2] and points to a complex coupling between the Fe moments.

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[2] P. Schobinger-Papamantellos et al. J. Alloys and Compounds 280(1998)44

Fr-PB140
RARE EARTH SUBSTITUTIONS IN A HIGH FREQUENCY Li-Zn FERRITE

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It is known that the preparation of the Li-Zn ferrite in dense polycrystalline form by conventional ceramic processing is difficult because the lithium evaporation implies a limitation of the sintering temperature. So we are mainly interested in the fabrication of dense polycrystalline specimens and we have previously investigated the influence of nonmagnetic oxide additives such as CaO, Na_2O, Sb_2O_3, ZrO_2 [1]. These oxides permit to obtain a substantially increased density at low temperatures without lithium loss. The aim of the present work is to evaluate whether the rare earth oxides have some influence on the ceramic parameters (grain growth, density, hardness), on the crystallographic (lattice constant) or on the magnetic properties (saturation magnetization, initial permeability, Curie temperature) of the Li-Zn ferrite. This influence on Ni-Zn ferrites has been previously published [2].

Six compounds with formula $Li_{0.3}Zn_{0.4}Fe_{2.26}R_{0.04}O_4$ where R≡Yb, Er, Dy, Tb, Gd and Sm were studied. The results obtained reveal that, by introducing a relatively small amount of R_2O_3 instead of Fe_2O_3, important modifications of properties can be obtained. For example, R_2O_3 shifts the Curie point of Li-Zn ferrite to lower temperature and increases the electrical resistivity with over one order of magnitude. We tried to explain these influences of the rare-earth ions as an effect of their ionic radius.

[1] N. Rezlescu, E. Rezlescu and M.L. Craus, Cryst. Res. Technol. **30** (1995) 33.
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Fr-PB141

MAGNETISM AND ELECTRICAL RESISTIVITY OF $ErCo_2$ UNDER HIGH PRESSURE

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Temperature dependence of the electrical resistivity $\rho(T)$ was measured between 4.2 and 300 K on polycrystalline $ErCo_2$ exerted to various hydrostatic pressures up to 8 GPa.
$ErCo_2$ belongs to the family of cubic Laves phase RCo_2 (R - rare earth) compounds. The compounds with nonmagnetic rare earths (Y, Lu or Sc) are exchange-enhanced paramagnets exhibiting metamagnetic behavior in high external magnetic field larger than 70 T. In the compounds with the heavy R (Dy, Ho, Er) magnetic ordering appears below T_C (= 33 K for $ErCo_2$). At this temperature the permanent R magnetic moments order ferromagnetically. As a consequence, a moment of $\approx 1\mu_B$ is induced on Co sites. Therefore, the magnetic phase transition at T_C is of first order and is accompanied by a drastic drop of ρ and an abrupt volume expansion. The applied pressure P affects considerably T_C and the absolute values of ρ in the paramagnetic region. Initially, the value of T_C becomes reduced linearly with increasing P, but beyond $P_c \approx 3.5$ GPa T_C becomes almost nearly pressure independent ($\approx$ 13 K). Also the $\rho(T)$ anomaly at T_C is considerably modified around 3.5 GPa pointing to a loss of Co magnetism at higher pressures. This behavior will be discussed within a model assuming above that for $P > P_c$ the Co-3d states at E_F become flat, Co moments vanish and the Er-Co-Er exchange channel becomes ineffective. However, the Er moments order at T_C (value comparable to T_C of $ErNi_2$) due to the persisting RKKY-type exchange interaction.

Fr-PB142

MAGNETIC PROPERTIES AND BAND STRUCTURE CALCULATIONS OF $YCo_{2-x}M_x$ WITH M=Cr, Ti

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The $YCo_{2-X}M_X$ systems with M = Cr, Ti form solid solutions having $MgCu_2$ -type lattice in the composition range $x \leq 0.3$. Magnetic measurements were performed in the temperature range 1.5K - 300K and fields up to 7T. At low temperatures, the magnetic susceptibilities follow a dependence in T^2, $\chi = \chi_0(1+aT^2)$. At temperatures higher than a characteristic value T*, a Curie-Weiss type behaviour is evidenced. The effective cobalt moments, M_{eff}(Co), decrease when increasing the content of substituting elements. For example, in case of M = Cr, the M_{eff}(Co) values vary from 3.86 μ_B for x = 0 up to 2.88 μ_B for x = 0.3. The experimental data were analysed in spin fluctuation model. Band structure calculations were also performed. The magnetic susceptibilities, at 1.5K, as well as their temperature coefficients a, in the low temperature range, are well described by using the computed density of states.

Fr-PB143
MAGNETIC PROPERTIES OF $Y_3Co_{11-x}M_xB_4$ WITH M=Cu OR Al

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The $Y_3Co_{11-x}M_xB_4$ with M=Cu or Al form solid solutions in the composition range $x\leq3$. Magnetic measurements were performed in the temperature range 4.2 – 800 K and fields up to 9 T. The compounds are ferromagnetically ordered. The saturation magnetization at 4.2 K decreases with increasing the content of substituting elements. The magnetic moments of cobalt atoms vary from $0.43\mu_B$ (x=0) up to $0.12\mu_B$ (x=3) for M = Cu. In case of Al system, for the compounds with $x\geq1.7$ a Pauli–type paramagnetism is evidenced in low temperature range. The effective cobalt moments are little dependent of composition and around $\mu_{eff}\approx2.00$ μ_B. The exchange interactions coefficients were computed. The cobalt magnetic moments show a metamagnetic transition for an exchange field around 50 T. Then the cobalt magnetic moment increases with increasing exchange fields according to the relation $\Delta M_{Co}=V_{Co}\Delta H_{exch}$ where $V_{Co}=(3\cdot10^2)^{-1}\mu_B/T$. Finally, we analyze the ratio between the number of spin determined from effective cobalt moments and saturation moments in correlation with exchange fields.

Fr-PB144
INSTABILITY OF THE Co-MAGNETIC STATE IN $Er_{1-x}Y_xCo_2$

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The magnitude of the magnetic moment per Co-atom (μ_{Co}) in the rare earth Laves phases RCo_2 depends on the value of the effective molecular field H_{mol}, acting from the R-subsystem. An increase of the yttrium content in $R_{1-x}Y_xCo_2$ compounds decreases H_{mol} and leads to the disappearance of the cobalt d-band splitting at the critical concentration x_c. In order to study the Co-magnetic state in the compounds $R_{1-x}Y_xCo_2$ near the critical concentration x_c we have investigated the electrical resistivity and small angle neutron scattering in the $Er_{1-x}Y_xCo_2$ pseudobinary series. It is shown that the concentration dependencies of the intensity of the small angle neutrons scattering I_d and residual resistivity ρ_{res} of compounds $Er_{1-x}Y_xCo_2$ have a maximum at the critical concentration $x_c=0.45$ where the Co-magnetic moment is unstable. The correlation between the behavior of the electrical resistivity and small angle neutron scattering was also observed on the temperature and field dependencies of I_d and ρ for the compound $Er_{0.55}Y_{0.45}Co_2$ with the critical yttrium content. Both the electrical resistivity and small angle neutron scattering are strongly influenced by the applied magnetic field. The obtained results are discussed taking into account an existence of the short range magnetic order in the R-subsystem and of the localized spin density fluctuations in the d-subsystem of $R_{1-x}Y_xCo_2$ in the neighborhood of the critical concentration [1].

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Fr-PB145

NOVEL FEATURES IN MAGNETIC PHASE DIAGRAMS OF $DyMn_2Ge_2$

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Magnetic and related properties of the ternary intermetallic compounds RMn_2Ge_2 are of great interest, in particular in view of the effects arising from coexistence of the 3d itinerant and 4f localized magnetic subsystems. The layer structure reflecting in high sensitivity of exchange parameters to the lattice spacing, the antiferromagnetic ordering in the Mn-subsystem in the case R=heavy rare earths and pronounced crystal-field effects of the R-subsystem result in their complicated and very interesting magnetic phase diagrams.
Our magnetization and magnetostriction measurements in pulsed fields up to 30 T for fine powder particles, fixed powders and polycrystals of $DyMn_2Ge_2$ together with available data of detailed magnetization (in fields up to 15 T on single-crystals) and neutron-diffraction studies [1] and Mossbauer and neutron-diffraction studies [2] in a wide temperature range were interpreted in the frames of the molecular field theory. New in respect to those found in [1, 2] metamagnetic field-induced phase transitions were identified both along and perpendicular to the tetragonal axis. The set of the Mn-Mn, Dy-Mn and Dy-Dy exchange and crystal-field parameters was determined which gives a fair agreement between calculated and experimental H-T diagrams.

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[2] Venturini G., Malaman B., Tomala K., Szytula A., Sanchez J.P. // Phys. Rev. B, 46, (1992), p.207.

Fr-PB146

TIME-DEPENDENT EVOLUTION OF MAGNETIC AND CRYSTAL STRUCTURE AND MAGNETIC SHAPE MEMORY EFFECT IN Ni_2MnGa ALLOYS

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Kinetics of martensitic transformation, change in the preferential martensite variants, field–induced strain (up to 6%) and magnetization under applied magnetic field are studied in-situ. Using X-ray diffraction, it is firstly shown that transformation under applied magnetic field in the alloy Ni_2MnGa is being developed with time at constant values of the field and temperature.
The results of X-ray diffraction study are compared with the in-situ optical metallography study of the martensitic structure changed with time under the applied magnetic field and after the field was taken out. A strong difference in the time-dependent behaviour of the first and second order twins has been found.
The change in the intensity of X-Ray diffraction reflections of martensite under applied magnetic field and in the structural evolution studied using metallography is found to be consistent with the measured values of the time-dependent field-induced strain, reversible strain and the observed residual strain.
The obtained results are discussed based on the effect of the applied magnetic field on the appearance and moving of the twins in the different martensite variants.

Fr-PB147

LARGE MAGNETIC SHAPE MEMORY EFFECTS AND INFLUENCE OF MECHANICAL LOADING ON MSME IN SINGLE CRYSTALLINE Ni-Mn-Ga FERROMAGNETIC ALLOY

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Effect of mechanical loading on the magnetically-induced strain in Ni-Mn-Ga alloys was studied in a view of their promising practical applications as actuators and sensors. Two single crystal samples were cut from the big grains of the non-stoichiometric Ni_2MnGa alloy. The studied specimens had the magnetically-induced strain of 0.083 % after homogenisation and revealed no clear magnetic anisotropy. The easy direction of magnetization was induced due to a complex of the mechano-magneto-thermal treatment.
Two ways of shape memory strain were studied: reversible strain caused by the change of the direction of the magnetic field and that caused by the change of the value of the field at the same its direction. The largest reversible strain more than 5,7 % was obtained due to the change of the direction of the magnetic field.
An effect of the orientation of the stress and magnetic field, effect of the stress and magnetic cycling on the reversible strain was studied. The largest reversible strain (shape memory effect) more than 2,5% under cycling the magnetic field is firstly obtained. The obtained results are illustrated and compared with those of the measurements of magnetisation, studies by means of optical microscopy and X-ray theta-two-theta analysis.

Fr-PB148

THE TOPOLOGICAL DESTRUCTION OF PHASE TRANSITION TO A SPIN GLASS STATE IN AMORPHOUS BULK ALLOYS WITH ASSIMETRICAL DISTRIBUTION OF EXCHANGE INTERACTIONS

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In this work the investigations of linear and nonlinear components AC response of bulk FeMn and FeNi amorphous alloys gave us the possibility to determine concentration dependencies of critical exponents β and δ for "paramagnetic-SG" phase transition near the critical concentrations $C_0=1$ of arising of long-range ferromagnetic order. The analysis of experimental results shows that the concentration dependencies of the critical exponents β and $1/\delta$ for these amorphous alloys in condition $C\to C_0$ corresponds to the values $\beta\to 0$ and $1/\delta\to 0$.
Our experiments confirm that the phase transition "paramagnetic-SG" destroys near C_0 of the arising of long ferromagnetic order. Using the obtained experimental data and its mathematical-processing we for the first time obtained the experimental estimation lower critical dimension $d_L=2.51\pm0.12$ for bulk SG that is very good agreement with the $d_L=2.5\pm0.2$ obtained by the method of high temperature expenses [1].

[1] Mc Millan W. L. // Phys. Rev., 30, (1984), p. 476.

Saturday, June 10, 2000

Saturday, June 10, 2000
Section A

Sa-IA01
MAGNETORESISTANCE OF THE Co/Cu/Co PSEUDO-SPIN VALVES

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We studied Co/Cu/Co pseudo-spin-vales (PSVs) to optimize their magnetoresistance (MR) performance. The PSVs were deposited with different buffer and capping layers on Si (100) wafers using S-research magnetron sputtering. Improved MR performance was achieved in PSVs with Fe buffer due to induced anisotropy along <100>. Sharp magnetization reversal resulted in magnetization "square loop", high MR value (9.2%), and enhanced field sensitivity (>1.0%/Oe) at low switching field (27 Oe). The magnetization reversal of the PSVs with Cr/Cu buffer was affected by the temperature and by the Cu spacer thickness, whereas the PSVs with Fe buffer showed excellent properties from 5 K to 300 K. The overall switching behavior in the PSVs with either Cr/Cu or Fe buffer layer is strongly influenced by the capping layer by affecting magnetic coupling between the two Co layers. The dependence of the MR values on the thickness of constituent layers of the PSVs was accurately interpreted within a model based on first principles solution to the Boltzmann transport equations calculations. In the calculations no adjustable parameters were used for material and transport parameters of the constituent layers. The transport parameters (e.g., the mean free paths) for Co (3.9 nm) and Cu (16.1 nm) were derived from Hall effect measurements from test samples deposited under identical conditions. The calculated MR values were in good agreement with the experimental ones within 5%.

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Sa-IA02
EFFECT OF LIGHT ILLUMINATION ON MAGNETIC PHASE TRANSITIONS IN MANGANESE OXIDES

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Some mixed-valence oxides of transition metals show changes of their properties under light illumination. Persistent photoinduced effects were observed in magnetic garnets, HTSC cuprates and recently have been found in manganites. Results of light effect on magnetic phase transitions in manganese oxides like manganites and garnets, containing Mn ions of two valencies, are reviewed.

In the AFM garnet $Ca_3Mn_2Ge_3O_{12}$ the illumination, with linearly polarized visible light, changes the field of the metamagnetic phase transition induced by a magnetic field. As a result of illumination, the transition field increases or decreases depending on the light polarization. The observed effect originates from the change of AFM state energy due to the photoinduction of magnetic moment. The orientation of the moment depends on the AFM state of sample and the light polarization. The visible light induces also the phase transition in $(Pr,La,Ca)MnO_3$ manganite from an insulator AFM state to a metallic FM one. Electrical transport and magnetization studies showed that the light is responsible for a partial transformation of the AFM phase. Relaxation of the photoinduced state of the manganite was not observed.

The mechanisms responsible for the photoinduced phenomena in manganese oxides are discussed. Effect of light on the magnetic phase transitions is related to the photoinduced charge transfer between Mn^{3+} and Mn^{4+} ions placed in nonequivalent positions of crystal lattice.

Sa-OA01
FMR - EXPERIMENT IN GRANULAR $Cu_{90}Co_{10}$ MAGNET

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FMR-spectra (derivative of microwave power absorption) were measured in granular, ribbon-shaped melt-spun $Cu_{90}Co_{10}$ alloy in a wide range of temperatures from 10 K up to room temperature. Prior to measurements the sample was annealed at 773 K for 1 h in order to create well-developed granular structure. The results obtained are interpreted using Kittel FMR-equations originally invented for thin films and Arrhenius-type exponential function for superparamagnetic relaxations as well as the results acquired from the low field susceptibility measurements in both, zero-field-cooling and field cooling modes.
It is shown that FMR-spectroscopy is a useful tool to study magnetic properties of granular magnets consisting of nanometer-scale single-domain particles, in particular, if the resonance spectra are measured in a wide range of temperatures allowing to identify magnetic phases of the particles. It is also demonstrated that the appropriate value of the characteristic time for superparamagnetic relaxations equals 10^{-13}s instead of 10^{-9}s most often taken in the analysis of the data obtained when using only one measuring instrument. An analysis of the results of measurements allows to estimate the first order constant of the magnetocrystalline anisotropy for fcc-Co (the particles exhibit this type of structure which is constrained by the copper matrix) which equals $K_1 = -4.2 \times 10^6$ erg/cm^3.

Sa-OA02
THE ROLE OF SPIN ACCUMULATION IN THE MAGNETORESISTANCE OF A SINGLE DOMAIN WALL

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To investigate the domain wall magnetoresistance (DW-MR) it is desirable to have an isolated domain wall with a well defined geometry in which other contributions such as the anisotropic magnetoresistance (AMR) or Lorentz magnetoresistance do not mask the DW-MR. We have recently demonstrated that such a desired configuration can be achieved in Co and Ni nanowires of 35 nm diameter and 20 μm length, prepared by electrodeposition in a track-etched polycarbonate membrane [1]. In this systems the domain walls appear only across the short wire axis, separating two domains, with magnetisation parallel and antiparallel to the wire axis [1]. These domains walls are clearly evidenced by magnetic force microscopy. The enhancement of the resistance due to the presence of a isolated domain wall is clearly evidenced by transport measurements in Co wires of 35 nm in diametre. The deduced relative change in the resistivity is at least one order of magnitude larger than the one predicted from a model based on the mixing of spin channels occurring over the lengthscale of the domain wall width [2]. This inconsistency can be resolved by taking the effect of spin accumulation into account, which scales in the case of Co over the much larger distance of the spin diffusion length.
[1] U. Ebels, A. Radulescu, Y. Henry, L. Piraux and K. Ounadjela; Phys. Rev. Lett (in press).
[2] P.M. Levy and S. Zhang, Phys. Rev. Lett. **79**, 5110 (1997).

Saturday, June 10, 2000
Section A

Sa-OA03

LONG- AND SHORT-RANGE MAGNETIC ORDER IN GRANULAR ARRAYS WITH DIPOLAR COUPLING

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In granular systems the common Langevin behavior of long-range order: $\langle\mu\rangle/\mu = L(\mu H/T)$, ($\mu$ being the granule magnetic moment, **H** the magnetic field, T temperature, $L(u) = \coth u - u^{-1}$) and of short-range order: $\langle\cos\theta\rangle = (\langle\mu\rangle/\mu)^2$ (θ the angle between neighbor moments), is generally affected by dipolar forces. To model this effect in granular layers, the energy of a planar square lattice (with period a) of dipolar coupled N granules under in-plane field **H** $\|$ x is expanded in Fourier components of small deviations from saturation $m^y = \mu^y/\mu$ (in-plane) and $m^z = \mu^z/\mu$ (out-of-plane): $E = N\varepsilon_0 + \sum_k[\varepsilon_k^{(y)}(m_k^y)^2 + \varepsilon_k^{(z)}(m_k^z)^2]$. The ground state energy per granule is: $\varepsilon_0 = -\mu(H + \alpha\mu/a^3)$ with $\alpha = \sum_{n\neq 0}\sum_{n'\neq n}(n^2 + n'^2)^{-3/2} \approx 9.154$, and two modes of collective excitations at $ak<<1$ are: $\varepsilon_k^{(y)} = \mu(H/2 + 2\pi\mu k_y^2/ka^2)$ and $\varepsilon_k^{(z)} = \mu(H/2 + 3\alpha\mu/2a^3 - 2\pi\mu k/a^2)$ (the out-of-plane mode $\varepsilon_k^{(z)}$ stays well positive at $ak \geq 1$). Then the parameters $\langle\mu\rangle/\mu = 1 - \gamma T$, and $\langle\cos\theta\rangle = 1 - (\langle\mu\rangle/\mu)^2\gamma' T$, where $\gamma = (4N)^{-1}\sum_k[1/\varepsilon_k^{(y)} + 1/\varepsilon_k^{(z)}]$ and γ' differs from γ only by additional factor $(\cos ak_x + \cos ak_y)$ under the sum, are defined self-consistently, substituting $\langle\mu\rangle$ for μ in $\varepsilon_k^{(y,z)}$. The numeric results for $\mu = 5\cdot 10^3\mu_B$, a = 5 nm and T = 300 K show a strong enhancement of $\langle\mu\rangle/\mu$ vs the Langevin limit, in a fair agreement with recent measurements for a discontinuous multilayered CoFe-Al_2O_3 system.[1] Also, a considerable value of the short-range correlation parameter $\sigma = \langle\cos\theta\rangle - (\langle\mu\rangle/\mu)^2$ obtained at low fields $H<<\mu/a^3$, suggests an important effect of dipolar forces on magnetotransport properties in such materials.

[1] G.N. Kakazei et al, IEEE Trans. Magn., **35**, 2895 (1999).

Sa-OA04

MONTE CARLO SIMULATIONS FOR MODELS OF DIPOLARLY INTERACTING FINE MAGNETIC PARTICLES

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Systems of dipolarly coupled classical spins with uniaxial anisotropy and an isotropic distribution of anisotropy axes are used as schematic models of interacting fine magnetic particles. The spins are placed on sites of lattices with varying numbers of nearest neighbors N, i.e. tetragonal lattices with N=2 and 4, the diamond lattice, simple cubic, fcc and bcc lattices with periodic boundary conditions. Ewald summation is used to treat the dipolar interactions. Results of Monte Carlo simulations are reported considering various aspects of the magnetic properties of these models, specifically hysteresis at zero temperature and at finite temperature, temperature dependent magnetization, non-equilibrium simulations of the response in alternating fields and relaxation response on finite field jumps (magnetic viscosity). These results establish dependencies of magnetic properties on the underlying spatial distribution of the particles for these models. The results are discussed in relation to current mean-field theories for the magnetic properties of ensembles of magnetic fine particles.

Saturday, June 10, 2000
Section B

Sa-IB01
HYSTERESIS AND MAGNETOSTRICTION IN HETEROGENEOUS SYSTEMS AT LOW TEMPERATURES

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Effect of heterogeneities of the ordered solids' structures on their magnetic and elastic properties during formation of low temperature phase and its destruction by a magnetic field is investigated in order to elucidate the interplay of the ordering processes in crystal lattice, electron and magnetic subsystems, possibilities of their common analysis and a creation of physical basis for prediction of the performances of the cryogenic devices on their basis. During fulfillment of the project the computerized experimental set was created for simultaneous measurements of the magnetic and size characteristics under thermocycling conditions, for structural investigations at low temperatures; technologies for preparation of the samples with the specified lattice heterogeneity, particularly multilayerty, determined by cellular decomposition of the supersaturated solid solutions in the external field were worked out. In the work the size effects were observed and studied in detail at the spontaneous low temperature transitions, as well as magnetostriction effects at the field induced transitions, i.e. giant irreversible magnetostriction in the layered compounds with giant magnetoresistance and high temperature superconductivity, and also remanent magnetic induction in the sample. The contributions of composition, strain effects and those of magnetic structure interactions with the lattice defects into the observed phenomena were distinguished. The analysis of the obtained results allowed to propose the model description of the low temperature ordering processes in the compounds with heterogeneous distribution of the point defects, and of magnetostriction in superconductors.

Sa-IB02
BIOMAGNETISM UPDATE

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In twenty years Biomagnetism passed nearly complete maturation period. From early hand made SQUID devices in physical laboratories, measuring magnetic cardiograms of students around, to dozens of well equipped research centers, using magnetometers with hundreds of SQUIDs inside full scale magneticaly shielded clinic offices, with sophisticated data processing units and multidisciplinary staff. All this development should be attributed to the field of bioengineering, which provided basically new, quite complicated tool for the study of living organisms, human being in particular. MultiSQUID systems can measure magnetic field configurations generated by the body with high spatial and temporal resolutions. Technologically, these systems reached in essence their classical shape, and future developments are very much dependent on the possible fundamental results obtained in biomagnetic research.

Most challenging problem in biomagnetic research is brain study, both clinical and fundamental. Multichannel magnetometers measure field distribution with high accuracy, though the problem is to interpret the data. Usually multiple sources of electrical activity in the brain are active simultaneously and contribute to the magnetic encephalogram. Interrelation between these activities is of value for understanding of the brain performance and clinical diagnostics. Solution of the inverse problem for the reconstruction of these multiple sourses is the major task. Combined studies using multichannel magnetometers and functional magnetic resonance imaging is quite promising avenue for the development.

Sa-IB03
MAGNETOREGULATED INTRAOCULAR ARTIFICIAL LENS

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Magnetoregulated intraocular artificial lens (MIAL) has 2 chambers: optical chamber and additional one connected by channel. Both channels are filled with the transparent liquid having the refractive index more than 1.336.
The anterior side of the optical chamber is made of elastic transparent membrane like silicon. The posterior side of the additional chamber is presented by elastic membrane. A fragment of magnet is fixed to the inner surface of the elastic membrane.
An initial state of the optical system of the MIAL is adapted for far vision. At the moment of near vision the outer magnet appears in front of the implant. The magnet fragment being over influence of the outer magnet displaces forward and pushes liquid from additional chamber to the optical one. The anterior surface of the optical chamber became steeper. Optical power of MIAl increases.
At the moment of far vision magnet moves back, liquid from the optical chamber returned to the additional chamber. Optical power of the M IAL decreases.
The outer magnet should be located into tissue of the lower lid or at the edge of orbit.

Sa-OB01
ELECTRICAL RESISTIVITY OF $RMn_{12-x}Fe_x$

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We have studied the electrical resistivity of polycrystalline $RMn_{12-x}Fe_x$, where R=Er, Ho, and x=4, 5 and 6, in the temperature range 4-300 K. These intermetallic compounds order antiferromagnetically at about 230 K and ferromagnetically below approximately 20 K. As the temperature decreases through the Neél point, the resistivity rises sharply, up to a maximum value at a lower temperature, and, in some samples, drops abruptly at the Curie point. A simple model, which includes spin disorder, phonon, and impurity scattering may account for the anomalous resistivities. In this model, a change in the Fermi surface brought about by the antiferromagnetic energy gaps is taken into account. The average magnetic moments of the 3d and R sublattices as well as exchange interactions constants, determined recently for these compounds [1], have been used in our calculations. The agreement between experiment data and calculated quantities is satisfactory.

[1] M. Morales, PhD thesis, Université Joseph Fourier-Grenoble 1 and Universidad de Zaragoza, unpublished.

Sa-OB02

NANOCRYSTALLINE Fe POWDERS ANALYZED BY ELECTRON HOLOGRAPHY

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It is now well established that the macroscopic magnetic behaviour of nanocrystalline materials, consisting of nanograins and a large fraction of grain boundaries, is strongly determined by their structural features. It is expected that the magnetic domains configuration and its thermal evolution reflect this dependence on the microstructure, besides being affected by the geometrical shape of the investigated sample. In this work, we report some preliminary results of electron holography observations on pure nanocrystalline Fe powders obtained by mechanical attrition through ball milling. In the present case, the mean diameter of the single Fe powder particle ranges between 1-5 μm and the average grain size is of the order of 15 nm.
The capabilities of electron holography to diplay magnetic flux lines have been used to record the stray field configuration around isolated nanocrystalline Fe particles and to obtain useful information on their magnetisation state, both at room temperature and at higher temperatures up to 1000 K. The presence of largely extended magnetic domains has been inferred which supports the hypothesis of exchange magnetic interactions acting among the nanograins.

Sa-IG01

MAGNETISM IN HARD NANOCOMPOSITES

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In nanocomposite systems with typical composition $Nd_4Fe_{76}B_{20}$, hard $Nd_2Fe_{14}B$ grains are intimately intermixed with soft α-Fe and Fe_3B grains. Remanence enhancement and a significant coercivity may exist [1] , determined by exchange coupling between soft and hard grains [2] .
The magnetic properties of these materials were recently analysed by detailed magnetisation measurements, complemented by XMCD (X-ray Magnetic Circular Dichroism) selective magnetometry allowing the hard and soft phase contributions to magnetisation reversal to be unambiguously separated [3] .
In the present study, it is shown that both the soft and hard phases contribute to remanence enhancement. This may be understood within a simple analytical model. A quantitative description of this effect requires numerical simulation.
Reversal of the soft grain magnetisation is described similarly within a simple analytical model and numerical simulation. From the thermal variation of the soft phase reversal critical field, it is suggested that a reduction of the exchange strength occurs at grain interfaces.
Hard phase magnetisation reversal in nanocomposites is essentially of the same nature as in usual hard NdFeB magnets. In return, the results obtained shed light on the magnetization reversal processes in NdFeB magnets in general.

[1] Coehoorn R., de Mooij D.B., Duchateau J.P.W.B., Buschow K.H.J.// J. de Physique, 49, (1988), p.669.
[2] Kneller E. and Hawig R. // IEEE Trans. Mag., 27, (1991), p. 3588.
[3] David S., Mackay K., Bonfim M., Pizzini S., Fontaine A., Givord D., presented at MRS Spring Meeting, San Francisco, April 1999 (to appear)

Sa-IG02

PHASE TRANSFORMATIONS AND PHASE TRANSITIONS IN GLASS-FORMING LIQUIDS AND DISORDERED SPIN SYSTEMS

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In contrary to naive ideas on homogeneity and isotropy significant structural and compositional nanoscale inhomogeneities are revealed in these states. These inhomogeneities essentially impact phase transitions in the spin system of a glass and determine its magnetic properties. The report includes results of investigations of the nature of the inhomogeneities of glass-forming liquids and glasses and their manifestations in properties of glassy magnetics .
In [1] the theory of the heterophase glass-forming liquids is presented. These states are essentially inhomogeneous on a mesoscopic scale. Heterophase fluctuations are nonperturbative in essence. Strong heterophase fluctuations form percolating clusters and their topologic properties is a topic of the percolation theory. The averaged on mesoscopic scale picture is reduced to description of the classic field of an order parameter fluctuations. The fraction of solid non-crystalline clusters in liquid is chosen as the order parameter. Correlation length of the order parameter is a characteristic scale of inhomogeneities. In fact, the heterophase liquid state is analogous to Griffiths phase of disordered spin systems.
Peculiarities of magnetic properties of glasses are analyzed briefly. Some selected experimental results are discussed.

[1] A.S. Bakai, Low Temp. Phys., **20**, 373, 379 (1994); **22,** 733 (1996); **24**, 20 (1998)

Sa-IG03

NOVEL PROBES TO LOCAL MAGNETISM AT SUB-MICRON TO NANOSCALE

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The current trend towards to higher and higher storage densities almost approaching nanoscale entities and the technology which goes with it requires that we develop more reliable and precise local information on a magnetic surface or its entities. With this goal in mind we have developed two new techniques to measure and map:

1) the local susceptibility, its magnitude and orientation over a surface using a crossed read/write recording Head, and
2) local magnetostriction and domain wall width at the surface of a magnetic dot using non-invasive technique which involves an atomic force microscope with a non-magnetic tip.

The information obtained, and the versatility of the two techniques mentioned above will be illustrated from measurements on the granular magnetic structure in magnetic ink, credit cards, melt quenched high-Tc surface below the superconducting transition temperature, magnetic dots, and patterned media produced by various techniques. Surprisingly our studies suggest that the magnetostriction values obtained locally on magnetic Co-dots are at least two orders of magnitude larger than what is known for bulk cobalt.

SEMINAR

Selected topics on dynamics and structure of magnetic materials

In memorizing of Professor Alex Hubert

Organizing Committee

Victor Baryakhtar, Institute of Magnetism, Kiev, Ukraine
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Thursday, June 8, 2000
SEMINAR "Selected topics on dynamics and structure of magnetic materials"
In memorizing of Professor Alex Hubert

Th-S01

ALEX HUBERT: A CREATIVE AND OUTSTANDING SCIENTIST

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This lecture reviews the early and recent activities of Alex Hubert when he published a number of pioneering papers in the field of micromagnetism. He started his scientific career with a big bang: The application of the optimized magnetooptical Kerr effect for the study of domain patterns. Later on he published fundamental articles in the following fields:
1. The basic rules for the arrangement of magnetic domains. 2. The theory of domain walls in bulk and thin film materials. 3. The development of the computational micromagnetism. 4. The phase diagram of domain walls in thin films. 5. The spin arrangements in small particles and the phase diagram of magnetic structures.
The method of Alex Hubert, how to relate microscopic magnetic properties with macroscopic phenomena will be discussed for some problems which have been solved by Alex Hubert.

Th-S02

THE ANALYSIS OF HIDDEN MAGNETIC DOMAINS

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Domain observation in bulk metals is restricted to the surface for most imaging techniques. Information about internal domains can be obtained from surface studies only in favorable cases as will be shown on several examples. Exceptional is a Fe(12.8at.%)Si alloy. It precipitates sub-microscopic platelets on annealing that are oriented along the magnetization direction. Domain patterns can be frozen-in by this method, so that their three dimensional structure can be analyzed in detail.

Thursday, June 8, 2000
SEMINAR "Selected topics on dynamics and structure of magnetic materials"
In memorizing of Professor Alex Hubert

Th-S03

DOMAIN WALL AND BREATHER KINETIC IN FERROPMAGNETS AND ANTIFERROMAGNETS

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We analyze the kinetic behavior of localized excitations - solitons (domain walls) and brithers for both easy plane anisotropy antiferromagnets and ferromagnets. Collision integrals for all type of localized excitation collision processes are constructed, and the kinetic equations are derived. We prove that the entropy production in the system of localized excitations takes place only in the case of inhomogeneous distribution of these excitations in real and phase spaces. The diffusion, internal friction and thermal conductivity coefficients for domain walls and brithers are calculated, and their temperature dependence is investigated. It is shown that diffusion processes in real space are much faster then the diffusion processes in phase space

Th-S04

VERTICAL BLOCH LINE DYNAMICS IN BUBBLE GARNET FILMS

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We will present a detailed comparison of experimental data with calculations about the dynamics of a single vertical Bloch line (VBL) within a single straight domain wall. Experimental data, obtained through the anisotropic dark field observation technique [1], give information both on the wall average displacement and its shape across the film thickness, position-resolved along the wall length and with a time resolution of 10 ns. Calculations were performed in three dimensions using the Slonczewski equations with, in comparison to the usual computations, a complete evaluation of the demagnetizing field. This is necessary because the VBL optical contrast is linked to a local wall tilt that results from the magnetostatic energy of the VBL.
Unexpected VBL contrast variations have been understood through the calculations. A quantitative agreement has been found for the VBL motion and contrast temporal evolution, using the same Gilbert damping constant that was determined for the pure Bloch wall experiments [1].
Conclusions are drawn on this effective value of the damping constant, higher than that determined from the frequency-dependent FMR linewidth.

[1] Patek K., Thiaville A. and Miltat J. // Phys. Rev. B, 49, (1994), p.6678.

Th-S05

SYMMETRY OF DOMAIN STRUCTURES AND DOMAIN BRANCHING IN MAGNETICS AND SUPERCONDUCTORS

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Similar to description of the crystal symmetry by space groups the symmetry of domain structures is shown to be described by Kleinian groups. It allows to build a classification of domain structures for magnetics and superconductors and explain their main properties. In the report we study mainly the domain branching, i.e. the hierarchical, self-similar and fractal splitting up of the domain on a boundary of solid. Different types of the domain branching on a plane boundary of magnetics and superconductors are considered. The domain branching leads to a natural thickness of the domain boundary and in such a way determines the limitations for usage of magnetic domains for storage and reproducing of information. Possible generalizations of the theory is considered with an aim to take in account the more general types of fields, the symmetry of crystal lattice, the 3-dimensionality of space and other types of boundaries.

Th-S06

EXCITATION OF BLACK SPIN WAVE ENVELOPE SOLITONS IN FERROMAGNETIC FILMS

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Most experimental work on spin wave envelope solitons in ferromagnetic films concerns bright solitons. The aim of this work was to study the possibility to generate true black solitons. The main experimental idea was to use the beating of two equal-amplitude co-propagating waves of slightly different carrier frequencies. When the amplitudes of these co-propagating waves are sufficient to activate the four-wave nonlinear mechanism, a train of fundamental black solitons is expected to develop. The results obtained in the work represent the first experimental demonstration of this technique.

Surface spin waves propagating in a 7.2 μm thick yttrium iron garnet film were used in our measurements. The input carrier frequencies were chosen to be around 4.2 GHz. The bias magnetic field was adjusted to ensure that all nonlinearly generated harmonics lie inside the surface wave bandwidth of the experimental film sample. To study the generation process of solitons in detail, the carrier frequencies and amplitudes of the input microwave signals were systematically varied to observe linear and nonlinear regimes. An effective generation of black soliton trains was observed with an increase of the input powers. The time distance between neighbouring solitons in the train was determined by the beat frequency of the carrier signals. Black solitons of one and the same width of 7 ns were formed in a range of the beat frequencies of 40 MHz. The observed phenomenon can be well explained in terms of nonlinear Schroedinger equation model.

Th-S07

PHASE CONJUGATION OF LINEAR AND NONLINEAR SIGNALS OF MAGNETOSTATIC WAVES

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Phase conjugation of magnetostatic waves (MSW) in yttrium iron garnet (YIG) films has been investigated both experimentally and theoretically. The experiment was performed using parametric pumping localized in area with lengths from the values less than length of carrier MSW to the values appreciably more than length of MSW's free path. The inversion ratio of conjugated wave and amplification ratio of transmitted wave have been measured for different values of pumping area length, pumping power and duration, and other parameters. The inversion ratio of 35 dB and amplification ratio of 40 dB were reached. The theory of interaction of magnetostatic waves with localized nonstationary parametric electromagnetic pumping was developed. The calculation of the inversion and amplification coefficients, as well as the theoretically predicted shapes of conjugated signals show good agreement with experimental data.
New method of direct measurement of MSW's relaxation time based on the phase conjugation technique is proposed.
The inverse of the shape of complicated input signal has been realized.
The phase conjugation of magnetostatic wave envelope solitons was observed. The possibility of soliton formation from conjugated wave packet and features of soliton amplification process are discussed.

Th-S08

HIGH POWER ULTRANARROW SOLITARY WAVES IN MAGNETIC THIN FILMS

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Solitary waves or solitons in thin films are usually modeled by the nonlinear Schroedinger (NLS) equation, which contains cubic nonlinearity and quadratic dispersion. The validity of the NLS model depends on the assumption that the pulse width is much greater than the carrier wavelength so that higher order dispersive terms can be neglected. Furthermore, the pulse amplitude must be small so that the cubic approximation is valid. In order to model the propagation of narrower and higher amplitude pulses, it is necessary to include higher order terms in the NLS equation.
Exact solitary wave solutions of the NLS equation with higher order nonlinearity and higher order dispersive terms are presented. In particular, both bright and dark solitary wave solutions of the NLS equation with fourth order nonlinear dispersion, second order nonlinear dispersion, as well as third and fifth order nonlinearity are presented. Moreover, higher order linear and nonlinear dispersion coefficients in the NLS equation applicable to yttrium iron garnet films are calculated.

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Th-S09

SPIN-REORIENTATIONAL TRANSITIONS AND MAGNETOELASTIC SOLITONS IN EASY-PLANE ANTIFERROMAGNETS

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The work is devoted to theoretical research of influence of exposures (electrical and magnetic fields, mechanical stress) on a possible spin - reorientational phase transitions and on weakly non - linear excitations in "easy plane" antiferromagnets with magnetoelectric interaction. The diagrams of stability of phases are constructed, the spectrum of linear magnetoelastic waves is retrieved. Is exhibited, that with the help of exposures the parameters of magnetoelastic solitons (width, amplitude, rate of propagation) can be essentially modified. It is found that the stability of quasi-acoustic solitons and creation of quasi-ferromagnetic solitons of an envelope can effectively be controlled exposures. Classification of "easy plane" antiferromagnets whenever possible existence in them of a magnetoelastic long - short-wavelength Zakharov - Benney resonance for the first time is offered.

Th-S10

MAGNETIC VORTICES IN NONCENTROSYMMETRIC MAGNETIC CRYSTALS

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In magnetic materials without inversion symmetry magnetic vortices are stabilized by an antisymmetric exchange interaction, which can be represented as an energy contribution linear in the first spatial derivatives of the magnetization vector. The lecture reviews theoretical investigations of isolated vortices and vortex lattices in bulk noncentrosymmetric magnetic crystals and in such novel materials as magnetic superlattices and thin films. Major contributions to these studies are due to the collaboration with Alex Hubert [1-3].

Magnetic vortices represent intrinsically stable localized magnetic inhomogeneities in size of nanometers which can be realized in low coercitivity materials at zero field. The equilibrium structure and stability of the vortices were investigated systematically by numerically solving the differential equations. The phase diagram of the solutions indicates a number of phase transitions between isolated vortices and different modulated states.

Recently. vortex states have been observed in NiMn alloys [4]. Numerous experimental results on cubic helimagnets are also consistent with the existence of isolated vortices and vortex lattices.

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Th-S11

SOLITON - MAGNON SCATTERING AND NORMAL MODES FOR A MAGNETIC PARTICLES IN CIRCULAR GEOMETRY

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Scattering of magnons by the 2d topological unhomohenities like Belavin-Polyakov solitons (BPS) or magnetic vortices is studied. For BPS, analytical solutions of the scattering problem are constructed - exactly for the partial wave with the azimuthal number $|m| = 1$ (translational mode), and in the long-wave limits for the rest modes. For magnetic vortex case, by the combining of the analytical and numerical methods, the long-wave asymptotics of the scattering amplitudes for m = 0, 1 are found. Using this data, the normal magnon modes for the finite size magnets in inhomogeneous states are investigated. The frequencies of this modes can be much less that in the case of magnet with the same size and shape but with homogeneous magnetization.

This work was partially supported by the grant INTAS 97 – 31311 and by the grant 2.4/27 ``Tunnel" from the Ukrainian Ministry of Science.

Th-S12

THE EFFECTIVE MASS OF THE THREE - DIMENSIONAL LOCALIZED DISTRIBUTION OF MAGNETIZATION IN FERROMAGNET.

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Nowadays many theoretical works are devoted to the research of the various static and dynamic soliton decisions of the Landau-Lifshitz equation in magnets. The equations of movement of magnetization can be written utilizing the Lagrange function that corresponds to the Landau-Lifshitz equation. This approach is used for the description of properties of nonlinear magnetization waves, dynamic and topological magnetic solitons in papers of many authors. The static magnetization distribution was received by taking on account the invariants containing magnetization derivative to the second power and more senior magnetization derivatives than the second derivative in the exchange energy of ferromagnet. The effective mass of the three-dimensional localized magnetization distribution was calculated in the paper.
The effective mass was found for the movement of the automodel spherically – symmetric localized distribution of magnetization $\varphi_0 = \frac{A}{r}\left(e^{-\lambda_1 r} - e^{-\lambda_2 r}\right)$, where A, λ_1, λ_2 - are the constants expressing through the exchange constants and the external magnetic field, where $r = \left|(x - vt)\vec{e}_x + y\vec{e}_y + z\vec{e}_z\right|$ is the radius vector of the center of the magnetization distribution, , where v is the velocity of the localized magnetization distribution.

Th-S13

SPIN WAVE SPECTRUM AND RELAXATION IN NON-COLLINEAR $CsCuCl_3$ TYPE ANTIFERROMAGNETS

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The present communication is devoted to a theoretical analysis of spin in noncollinear antiferromagnets of the $CsCuCl_3$ type. This class of magnets is extremely interesting, since it exhibits both triangular magnetic ordering and an incommensurate structure and represents a fairly rare case of a modulated magnetic structure of relativistic-exchange origin, i.e., which results from the competition between the exchange interaction and the Dzyaloshinskii-Moriya interaction.

Dynamic property of the magnet is analyzed by means of the effective Lagrange function method using Cartan differential forms, taking into account a hexagonal anisotropy in the basal plane and an external magnetic field along the wave vector of the structure. A linear spin wave spectrum on the background of the modulated structure is found, describing one gapless branch and two branches with activation. The gapless branch with a linear dispersion law corresponds to the Goldstone mode with oscillations of sublattice magnetization vectors in the basal plane, that is typical for easy-plane magnets. Two other branches are associated with oscillations in which magnetization vectors deviate from the basal plane.

Spin wave damping is described by introducing a phenomenological dissipation function (also expressed by Cartan forms) into equations of motion and an external field dependence of a spin wave relaxation time is obtained.

Th-S14

TOPOLOGICAL MAGNETOSTRUCTURAL SOLITONS IN 2D ANTIFERROMAGNET CONTAINING A DISLOCATION

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We study the distribution of magnetization in the presence of dislocation in 2D antiferromagnet. We propose a two-dimensional model generalizing the Peierls model to the case of coupled fields of magnetization and elastic displacement distribution. In the frame of this model we obtain a system of nonlinear integrodifferential equations which has solutions for i) magnetic vortices and magnetic disclinations connected with dislocations in the case of strong one-ion anisotropy of easy plane type and no magnetic anisotropy in the easy plane, ii) domain walls and bound states of dislocations and domain walls if consider magnetic anisotropy in the easy plane.

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Fr-S01

SPIN-FLUCTUATION SUPERCONDUCTING PAIRING IN STRONGLY CORRELATED METALS

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Recently we have formulated a microscopical theory of electron spectrum and superconductivity in the limit of strong electron correlation within the *t-J* model [1]. The two-dimensional *t-J* model in a paramagnetic state was considered by employing a projection technique for the Green functions. To treat rigorously the constraint of no double occupancy in the *t-J* model the Hubbard operator technique was used. We derived in the noncrossing approximation and solved numerically the self-consistent Dyson equation in the Nambu notation by taking into account exchange and kinematical interactions of electrons with spin fluctuations. The latter were described by a dynamical spin susceptibility with short-range antiferromagnetic correlation. The single-electron spectral density revealed narrow quasi-particle (QP) peaks close to the Fermi surface (FS) with an additional broad incoherent band below the FS. The QP dispersion, being small at low doping becomes large for moderate doping. The occupation numbers $N(\mathbf{k})$ show only a small drop, increasing with doping, at the FS. The superconducting gap function $\Delta(\mathbf{k},\omega)$ and T_C were calculated by a direct numerical solution of the linearized equations. In the present report we generalise the theory for the asymmetric *t-J* model to describe orthorhombic phases of copper-oxides. We observed the *d*-wave symmetry of the gap in tetragonal phase and a mixed, *s+d,* symmetry in orthorhombic phase with T_c of the order 200 K at an optimal doping. The orthorhombic distortion suppresses T_c that explains recent experiments on the pressure dependence of T_c in LSCO and YBCO compounds.

Our calculations for the microscopical model with strong correlation support the spin-fluctuation mechanism of high-temperature superconductivity in copper-oxide compounds.

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Fr-S02

OVERLAP FOR QUANTUM SKYRMIONS IN 2D SPIN SYSTEMS.

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Skyrmions are general static solutions of 2D Heisenberg ferromagnet, obtained by Belavin and Polyakov [1] from classical nonlinear sigma model. A renewed interest to these unconventional spin textures is stimulated by high-T_c problem in doped quasi-2D-cuprates and quantum Hall effect. We consider some peculiarities of quasiparticle behaviour for the quantum skyrmion. First of all it implies the calculation of the overlap integrals $S_{12} = \langle \Psi(z-z_1) | \Psi(z-z_2) \rangle$. The simplest wave function $\Psi(z-z_1)$ of quantum skyrmion centered at a point z_1 is taken as a multiplication of spin coherent states that provides a maximal equivalence to classical skyrmion with minimal uncertainty of spin components.

Finally we obtain the overlap integral for skyrmion with radius λ

$$| S_{12} |= \exp[-\frac{\pi S R^2}{c^2}], \qquad | S_{12} |= \exp[-\frac{\pi S}{c^2}(R^2 - R\sqrt{R^2-4\lambda^2})](\frac{R+\sqrt{R^2-4\lambda^2}}{2\lambda})^{-\frac{4\pi S\lambda^2}{c^2}}, \qquad \text{for}$$

displacements $R<2\lambda$ and $R>2\lambda$, respectively. Here S is a spin quantum number, c is a lattice parameter. One should note the specific dependence of the overlap integral on the spin-site density $(1/c^2)$ and number of spin deviations $(2S)$.

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Fr-S03

ORBITAL MAGNETIC FLUCTUATIONS IN DOPED CUPRATES

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The CuO_2–planes in strongly correlated cuprates ($YBa_2Cu_3O_{6+x}$, $La_{2-x}Sr_xCuO_4$, $La_2CuO_{4+\delta}$,) are considered to be unstable with respect to disproportionation reaction with formation of the electron and hole centers which system appears to be equivalent to Bose-liquid [1]. These form the system of local singlet bosons, moving in the lattice of the effective hole centers. The valent multiplet for this center in doped cuprates includes both the orbital singlet ($^1A_{1g}$ Zhang-Rice singlet) and orbital doublet ^1E_u with non-quenched Izing-like orbital magnetic moment oriented perpendicular to the CuO_2–planes. So, there is a potential opportunity to observe the orbital moment with the help of nuclear magnetic resonance, muon spin resonance etc. Real situation in the doped cuprates implies an occurrence of a strongly inhomogeneous state with $^1A_{1g}$-^1E_u mixing due to static and dynamic low-symmetry crystalline fields and vibronic coupling. Thus, one might expect a manifestation of orbital magnetic fluctuations. The most favorable conditions are realized in the 2-1-4 type cuprates like
$La_{2-x}Ba_xCuO_4$ near the LTO-LTT transition from the low-temperature orthorhombic to low-temperature tetragonal structural phase, accompanied by the transformation of adiabatic potential for the CuO_4–centers from the $B_{2g}E_u$-type to $B_{1g}E_u$-type [2]. This transformation, in their turn, is accompanied by emergence of the well developed orbital current fluctuations, which could be detected in NQR-NMR and μSR experiments.

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Fr-S04

SPECTRAL DENSITY OF A HOLE IN FRUSTRATED ONE-DIMENSIONAL ANTIFERROMAGNET

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The spectral function of one hole in different magnetic states of the one-dimensional *t-J* model including three-site term and frustration J' is studied. In the strong coupling limit $J \to 0$ (corresponding to U $\to\infty$ of the Hubbard-model) an eigenoperator of the Hamiltonian is found which allows to derive an exact expression for the one-particle Green's function that is also applicable at finite temperature and in an arbitrary magnetic state. The corrections due to small exchange and frustration terms are found using the projection technique. The spectral function is discussed in detail, and explicit formulae are given, for: i) the pure *t-J* model with the ground-state of the Heisenberg model, ii) the special frustration $J'=J/2$ with the Majumdar-Ghosh wave function, and iii) the ideal paramagnetic case for infinite temperature. The results illustrate how the known features of spin-charge separation in the spectral function of the *t-J* model will be modified by frustration or temperature. Especially, it is found that the low-energy region between $\pi/2$ and π will be filled with states and the spinon dispersion becomes symmetric around $\pi/2$ in the case $J'/J=0.5$.

Fr-S05

SPIN DISCLINATIONS: CLASSICAL AND QUANTUM PROPERTIES

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Spin disclinations (vortices with half-integer vorticity Q) appear due to the frustration phenomena in spin systems with antiferromagnetic (AFM) exchange interaction. Well-known antiferromagnetic disclinations caused by atomic dislocation in biparticle lattice with AFM interaction [1, 2]. The screw dislocation for the layered AFMs, with ferromagnetic (FM) and AFM interactions inside layer and between layers, respectively, produce the defect, which could be called ferromagnetic disclination. The simplest models for description of such defects are closed spin chains with odd number of spins and a chain with AFM interaction between two spins and FM interaction for other spins, respectively. In classical case the ground state of spin disclinations is degenerated with respect to the sign of Q. The effects of tunnel change of the sign of Q on the ground of non-one-dimensional instanton solutions, with the taken into account the interference effects [3], are investigated.

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Fr-S06

INCOHERENT TUNNELING IN A SYSTEM OF INTERACTING MAGNETIC DIPOLES

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We simulate systems of spins with dipolar interactions. As in tunneling experiments in Mn_{12} and Fe_8 crystals at very low temperature, spins transitions are allowed between two states only if the energy changes only if the energy changes by a sufficiently small amount, less than W. We obtain the time evolution of the dipolar field distribution P(H) after the system temperature is suddenly lowered from the paramagnetic phase to a temperature well below the ordering temperature. As in tunneling experiments performed in Fe_8 clusters near 40 Mk, a "hole" develops in P(H) as time goes on. We study the relation between the hole width and W.

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Fr-S07

SUPERCURRENTS THROUGH THE JOSEPHSON π-JUNCTIONS

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A solid state implementation of the quantum bit based on a superconducting loop with a weak link with nonzero phase difference in absence of currents and magnetic fields ("π-junction") has been proposed recently. One of the ways of π-contact realization is the S/F/S Josephson junction, where exchange ferromagnetic field H_{exc} is responsible for the additional phase difference. This type of contacts recently has been realized and investigated [1,2]. In this report we present the results of calculation of the electrical properties of SFIFS and SFIS junctions as a functions of the strength of the proximity effect, S/F boundary transparency and value of the ferromagnetic exchange field. A microscopic model of the proximity effect in S/F layered structures has been studied for the case of a thick superconductor (S) and a mesoscopic ferromagnet (F). Both metals have assumed to be in the dirty limit. The spatial dependence of the order parameters in S- and F- metals, quasiparticle densities of states (DOS), and critical current I_C of SFIFS and SFIS junctions have been calculated. It is shown that in mesoscopic S/F structures the DOS is spin-polarized both in S- and F- metals. We have also obtained the $I_C(H_{exc})$ reantrant behavior with I_C vanishing for some values of the H_{exc}.

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Fr-S08

DISORDERED PHASE OF ANTIFERROMAGNETIC SPIN CHAIN $CsNiCl_3$

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The investigation of antiferromagnetic linear spin chains has attracted considerable attention ever since Haldane's conjecture. Most of the experimental and theoretical work on spin-1 chains has concentrated on the low temperature range (T<0.5 J), but little is know about the dynamic properties of antiferromagnetic spin-1 chains at higher temperatures. Using inelastic time-of-flight and triple-axis neutron scattering, we have investigated the excitation spectrum of $CsNiCl_3$ between 5 and 70K (~2 J). The Haldane gap in $CsNiCl_3$ has been measured between 5 and 70K at (0.81 0.81 1) in reciprocal space, where the 3D interaction vanish to first order. The excitation remains well visible up to T=70K and the static magnetic form factor decreases with increasing temperature as ferromagnetic fluctuations become more important. At 5K, the Haldane gap energy is 1.22 meV and it increases with increasing temperature until it is about three times bigger at T=70K. This substantial increase in the energy contrasts with the decrease with temperature seen in most antiferromagnets. The width of the observed excitation shows an activated temperature dependence at low temperatures and becomes temperature independent above T=50K. We compare the temperature dependence of the intensity, gap and width of the excitations with different theoretical models and recent numerical calculations.

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Fr-S09

PHONON AND SPIN DYNAMICS IN SPIN LADDER CUPRATES AND VANADATES

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The results of optical absorption and light scattering measurements in new magnetic materials, spin-ladder cuprates [1] ($Sr_{14}Cu_{24}O_{41}$, $SrCuO_2$) and vanadates [2] (AV_2O_5 ,A=Na, Li, Ca, Mg and Cs), will be presented together with results of electronic structure calculations of these oxides. A different resonant behavior of Raman scattering spectra of strontium cuprates is explained according to their electronic structure difference. In CaV_2O_5 we found the onset of magnetic continuum in the form of strong asymmetric line [3] which suggests the quasi one-dimensional magnetic ordering. Strong two-magnon peak points to the existence of the two-dimensional magnetic ordering in MgV_2O_5

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Fr-S10

EXPERIMENTAL AND QUANTUM TRANSFER-MATRIX SIMULATION DATA FOR $CuGeO_3$ SUSCEPTIBILITY

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Thermodynamical properties of the one-dimensional S=1/2 Heisenberg model with dimerized nearest and uniform next-nearest neighbour interactions are studied by the numerically exact quantum transfer-matrix method and the results are applied to $CuGeO_3$. The Suzuki-Trotter formula is used to obtain a classical system with spin σ=3/2 and effective interactions between nearest neigbours only. The magnetic susceptibility curve is calculated and compared with experimental results performed in a wide temperature range, revealing the presence of frustration in the model proposed for $CuGeO_3$. Temperature dependence of the dimerization parameter below the spin-Peierls transition point is also estimated.

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Fr-S11

TOWARDS THE RELATION BETWEEN ELEMENTARY EXCITATION SPECTRUM AND DYNAMIC STRUCTURE FACTOR: EXACT ANALYSIS FOR THE SPIN-1/2 XX CHAIN

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The dynamic structure factor, which can be derived from scattering experiments, yields valuable information about the origin of the properties of magnetic systems. In particular, the experimentally measured dynamic structure factor is related to the elementary excitation energy, however, a rigorous analysis of the relation between scattering peaks and dispersion law can be performed rather seldom. We consider the spin-1/2 transverse XX chain with the Hamiltonian

$$H=\Omega\sum_{j=1}^{N}s_j^z+J\sum_{j=1}^{N}\left(s_j^x s_{j+1}^x+s_j^y s_{j+1}^y\right)$$

and calculate exactly (analytically or numerically) the dynamic structure factor

$$S_{\alpha\beta}(\kappa,\omega)=\sum_{n=1}^{N}e^{i\kappa n}\int_0^\infty d\omega e^{i\omega t}\left\langle s_j^\alpha(t)s_{j+n}^\alpha\right\rangle,\quad \alpha\beta=xx,xy,zz$$

at low temperatures. We contrast the exact results for xx and zz dynamic structure factors. We compare our findings with the single-mode approximation $S_{-+}(\kappa,\omega)\sim\delta(\omega-E_\kappa)$, $E_\kappa=\Omega+J\cos\kappa$ and demonstrate that the latter expression is qualitatively wrong for $\Omega<J$.

Fr-S12

QUANTUM CHIRAL PHASES IN FRUSTRATED SPIN CHAINS

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In recent numerical investigations [1] it was found that anisotropic (easy-plane) S=1 XXZ spin chain with competing nearest- and next-nearest-neighbor antiferromagnetic exchange couplings exhibits the so-called quantum chiral phases characterized by a nonzero value of the chirality defined as $\kappa=<(\vec{S}_n\times\vec{S}_{n+1})_z>$. We discuss the appearance of gapless and gapped chiral phases with the help of a field-theoretical model, and show that their existence is not specific for S=1, but rather generic for arbitrary S, the case S=1/2 being an exception. For integer S, the transitions from the Haldane phase to the gapped chiral phase and from gapped chiral to gapless chiral phase are shown to belong to the Ising and Kosterlitz-Thouless universality classes, respectively.

[1] T.Hikihara, M.Kaburagi, H.Kawamura, and T.Tonegawa, e-print cond-mat/9910159; M.Kaburagi, H.Kawamura, and T.Hikihara, e-print cond-mat/9902002, to appear in J. Phys. Soc. Jpn.

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2D NONLINEAR EXCITATIONS IN EASY-PLANE FERROMAGNETS: SOLITONS AND VORTICES

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Two-dimensional nonlinear magnetic excitations of different types in ferromagnets with easy-plane single-ion or exchange magnetic anisotropy are investigated in the framework of Landau-Lifshitz and Tiele equations both analytically and numerically. It was shown that the moving small-amplitude 2D soliton with a stationary profile has the form of semitopological vorticity dipol and the numerical solutions for it was found. This soliton transforms into vortex-antivortex pair in the limit of its small velocities. An interaction of such pairs was studied in Tiele approximation and the phase shifts were found. The analytical solutions for the scattering of two pairs with nonzero total momentum or nonzero total angular momentum were investigated. We demonstrate that for different parameters of initial conditions the pairs can pass through each other without loosing their identity or scatter with the changing of the partners. They can also form the bound rotating configurations with one and two frequencies of rotation. In small amplitude limit the two-parametrical dynamic solitons were studied by using the asymptotic method. These solutions represent the objects with nonzero vorticity of dipol type too. In small velocity limit the similar solution has a structure of magnetic super-roton which consists of two vortex-vortex and antivortex-antivortex pairs.

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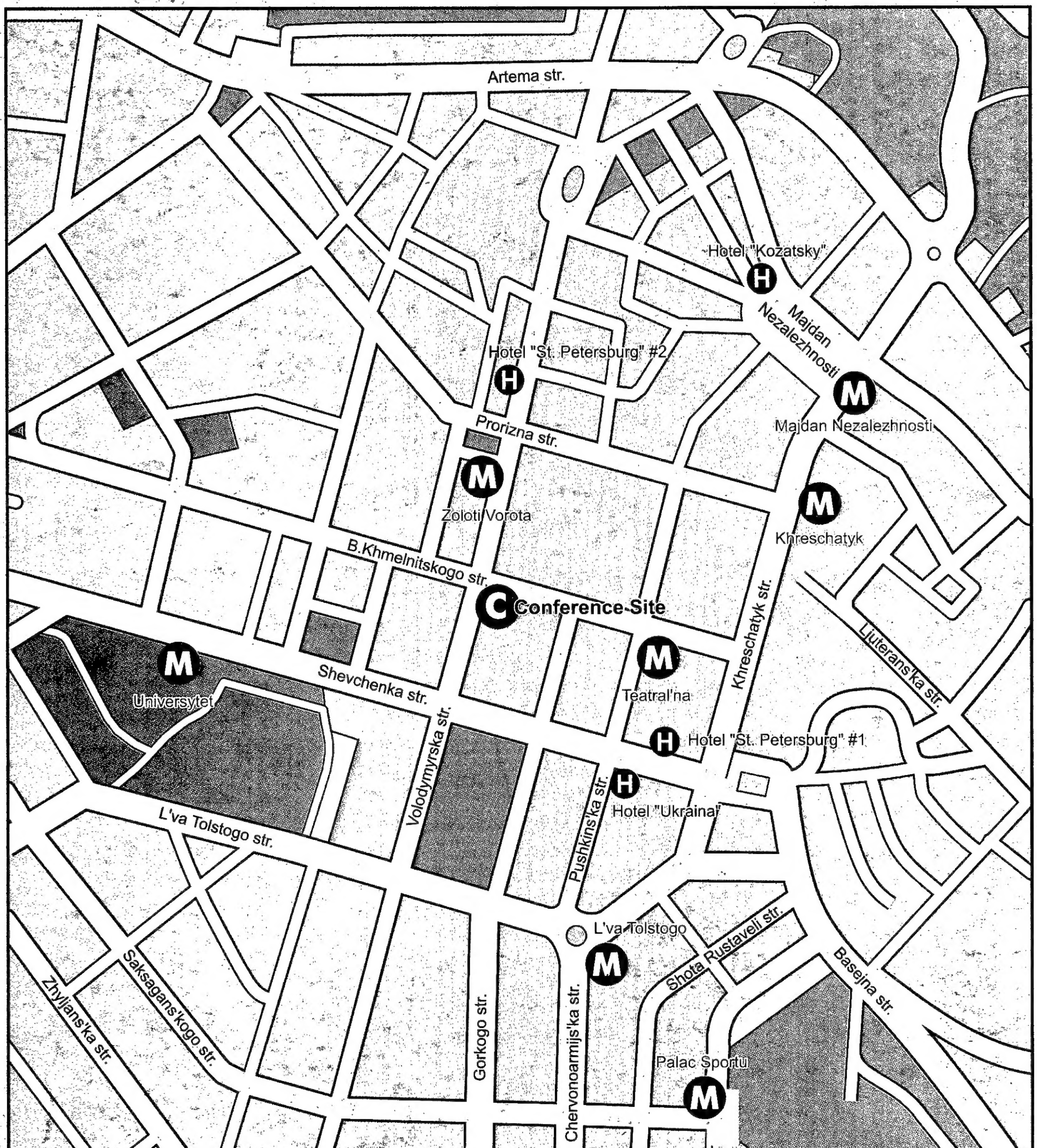

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